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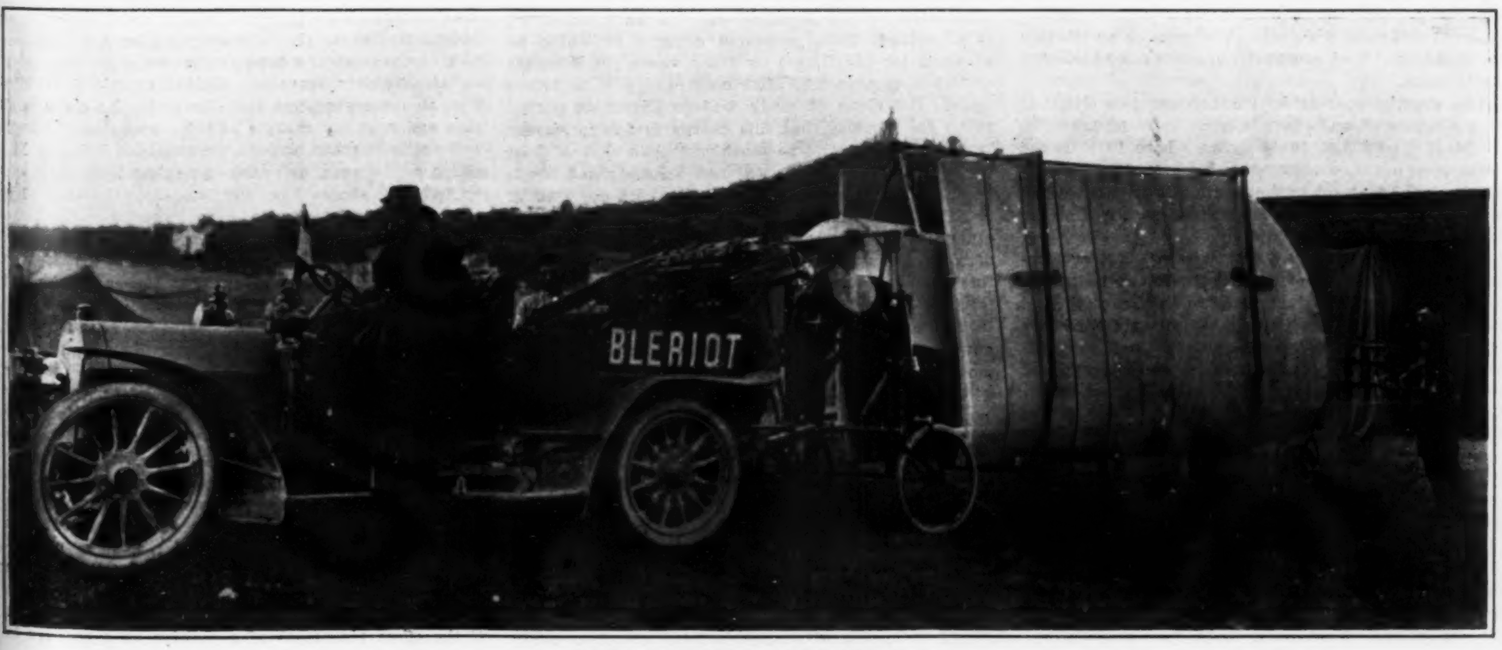
Lieutenant Blard Flying Over a Battery of Artillery in a Farman Biplane.



Automobile Hauling a Blériot Monoplane.

AEROPLANE SERVICE IN THE RECENT FRENCH MANEUVERS

Attempts to Explain Gravitation

Theories To Account for a Fundamental Property of Matter

Mr. W. C. Morris, writing in the *Popular Science Monthly*, gives a succinct review of some of the principal hypotheses which have been adduced in the endeavor to account in some rational way for that fundamental and universal, and yet so little understood phenomenon, the gravitation of matter.

Mr. Wilson prefaces his account by a brief survey of the history of our knowledge of the laws of gravitation.

"Kepler had stated in his first law that the earth revolves in an elliptical orbit with the sun at one focus. With this knowledge at hand, by strictly dynamical reasoning Newton showed that bodies attracted according to a definite law (the attraction between two bodies being directly proportional to the product of the masses and inversely as the square of the distance, if the dimensions of the bodies are small compared with the distance between them). Having enunciated this law he proceeded to verify it by studying the motion of the moon. The moon revolves in an orbit that is nearly circular and to keep it in this orbit there must be an acceleration toward the earth equal to V^2/r where V is the moon's orbital velocity and r is the distance from the earth to the moon (approximately 240,000 miles). In place of V we may put $2\pi r/t$, where t is the time of one revolution (27.3 days). Hence the acceleration toward the earth equals

$$\frac{V^2}{r} = \frac{\left(\frac{2\pi r}{t}\right)^2}{r} = \frac{4\pi^2 r}{t^2} = \frac{4\times 9.86\times 240{,}000\times 5280}{(27.3\times 86{,}400)^2} = .0089 \text{ ft.}/\overline{\text{sec}^2}.$$

The acceleration the earth should exert, if Newton's law be true, at a distance of 240,000 miles (60 times the earth's radius) $= 32.16/60^2 = 0.0089$ feet /sec² where 32.16 feet /sec² is the acceleration at the surface of the earth. The verification in the case of the moon is complete. Hence we have the mathematical statement of the law: F (the force)$=Mm/r^2 . G$ where G is a constant depending upon units only. We say nothing about the *quality* of the matter but only the *quantity*, and the *distance*. Notice also that there is no factor in the equation referring to the nature of the intervening medium."

It is interesting and instructive to compare the magnitude of the gravitational force between two portions of matter, with other forces to which they are subject. "We know to-day that the radiation from the sun exerts a pressure. Kepler suggested this three centuries ago, and one hundred and fifty years later the great mathematician Euler adopted his suggestion in accounting for the repulsion of comets' tails. So delicate is this pressure that it was not discovered until recently (1900). Albeit this pressure is very small as bodies diminish in size, we reach a limit at which it predominates over gravitation. This is due to the fact that gravitation is proportional to the mass (the cube of the linear dimension) while radiation-pressure is proportional to the surface (the square of the linear dimension).

When we consider electrons we find that the gravitational attraction between two electrons is insignificant compared with electrical attraction. The electrical force in air between two negative electrons one centimeter apart is equal to $(4.5 \times 10^{-10})^2 = 20 \times 10^{-20}$ dynes, if we take the charge on an electron to be 4.5×10^{-10} centimeter-gramme-second electrostatic units.

The gravitational attraction between two electrons at a distance of one centimeter $= 10^{-27} \times 10^{-27} \times 6.6 \times 10^{-8} = 6.6 \times 10^{-62}$ dynes, where 10^{-27} is the mass of a negative electron and 6.6×10^{-8} is the gravitational constant in the centimeter-gramme-second system. Comparing the two results, we see that the former is 10^{42} times the latter.

"In astronomical bodies gravitation is the predominant force. An idea of its magnitude can be gained by calculating the attraction between the earth and the moon, which are small bodies astronomically speaking. The earth's mass is about 6 times 10^{21} tons, which is 80 times the moon's mass, and the distance between the two is about sixty times the earth's radius; hence the attraction $= 6 \times 10^{21} . 1/80 . 1/60^2 = 2 \times 10^{16}$ tons of force. To hold this system while it rotates about a common center would require about five million-million steel bars each one foot square and of tensile strength of thirty tons per square inch Knowing the distance between the earth and the sun (23,000 times the earth's radius) and that the sun is about 330,000 times as massive as the earth, in like manner we can show that the force between the earth and the sun is greater than that of the earth and the moon. What must it be for double stars! Surely the origin of such gigantic forces ought to be worth careful study."

While gravitational attraction resembles the electrostatic force between two charged bodies in obeying the inverse square law, there is a marked difference between the two phenomena, in that electric forces are strictly dependent upon the intervening medium between the two charges, while gravitation is in no way affected by the nature of the space separating two gravitating bodies from one another. The question of the rate of propagation of gravitational effects is still an open one. Having thus briefly touched the discovery, law, magnitude and peculiarities of gravitation, we are ready to review the attempted explanations of its mechanism.

The modern tendency is to try to bring all physical phenomena under the scope of electro-magnetic effects. Kauffmann's experiments lead us to regard mass as electro-magnetic in character. Since gravitation is closely bound up with mass, it is very natural to try to explain it as an ether phenomenon. This would require the ether to be capable of supporting enormous pressure and tension. Many modern physicists regard the ether as very rigid and dense when compared with ordinary matter. Following Sir J. J. Thomson, we can calculate the density of the ether from the mass of an electron. The figure thus found is 10^{12}, or in other words, the ether is a million-million times as dense as water. Using this figure for the density, and remembering that the velocity of ether waves (light) is 3×10^{10} centimeters per second, the rigidity will be of the order of 10^{33} dynes per square centimeter, since the velocity is proportional to the square root of the quotient of the elasticity by the density. The intrinsic energy, if due to rotational motion, will be of the order of 10^{33} ergs per cubic centimeter, if we assume the velocity of rotation to be of the order of that light. Hence, the intrinsic energy and rigidity of the ether will probably meet the demands of an electro-magnetic theory of gravitation, if we accept the views of ether and matter held by some of the greatest modern physicists.

"If a falling body does not gather its energy from the ether where does it get it? Lift a ton to the height of 1,000 feet above the earth's surface and we have 2,000,000 foot-pounds of potential energy, or preferably a body that in returning to its original position will gather 2,000,000 foot-pounds of energy. Is this energy inherent in the body? Newton's letter to Bentley shows us that he was opposed to such a view.

"In the 'Principia' Newton makes no attempt to explain gravitation, but in one of his optical queries he writes thus: 'If the pressure in the medium is less in the neighborhood of dense bodies than at a greater distance from them, dense bodies will be drawn toward each other, obeying the law of gravitation if diminution of pressure is inversely as the distance.'

"Hooke, a contemporary of Newton and a man of great ingenuity, attempted a wave theory of gravitation from his observation that bodies floating on water agitated by waves were drawn toward the center of disturbance. The action of a body immersed in water was not considered. Since his time various attempts have been made to explain gravitation as due to a wave motion. At the last meeting of the American Association for the Advancement of Science, Mr. Brush, of Cleveland, Ohio, presented a paper in which he accounts for gravitation by ether waves. It demands an ether possessed of intrinsic energy. As before stated, the views of many modern physicists permit this. He assumes that this energy is due to waves; but the frequency is so much less than that of heat or light that molecules will not respond; and hence bodies do not become warm. He accepts the view of J. J. Thomson that all energy is kinetic energy of the ether. Before attempting to explain the mechanism of gravitational attraction he paves the way by referring to a well-known phenomenon in light. If we take an opaque body in a room with luminous walls it will experience pressure on all sides because we now know that light-waves have both energy and momentum. If we now introduce a second body each will be in the shadow of the other or screen the other; hence the radiation pressure is less on the side of each body which faces the other; and hence there will be a tendency for the bodies to be *pushed* together.

"Now, substitute for the light-waves waves of great length and less frequency, and owing to their low frequency they will affect the interior molecules as well as the surface ones, and hence we will have a volume or mass effect and not a surface effect as in light. This is in accord with Newton's law, for the force is proportional to the mass. 'We may picture . . . molecules of matter buffeted about in every direction by ether-waves in which they are entangled, like a suspended precipitate in turbulent water.' Now, introduce a second body and the pressure in the direction of the line joining these two is less than in any other direction, as each is in the 'shadow' of the other; hence they are *pushed* together. Mr. Brush's theory, like all other theories regarding gravitation, is beset with difficulties. If gravitation is due to a type of radiation transmitted at finite speed it ought to be subject to aberration as is light. To avoid this Brush takes longitudinal waves and assumes the elasticity of ether is such that their velocity is much greater than that of light waves which are transverse. Longitudinal waves in ether have not yet been detected.

"J. J. Thomson in his Silliman lectures enunciates a view somewhat similar to that given by Brush. In place of longitudinal waves he used short ether-pulses something like the Röntgen and gamma rays. This view presents the aberrational difficulty, as do other views which attempt to explain gravitation by a type of radiation. On this view any change in gravitation would be propagated with the velocity of light; and certain phenomena in astronomy seem to require the gravitational effect to be propagated much faster than light.

"Hence at present gravitation seems to be precluded from the electro-magnetic scheme, owing to speed of propagation. Since in the last ten years we have tried to unify, it is unfortunate that it rebels against admission into our scheme. Many have pronounced it a mode of activity in the ether not specified but entirely different from the electro-magnetic mode.

'Replace Brush's long waves or Thomson's short electro-magnetic pulse by rapidly moving corpuscles and we have Le Sage's theory. According to Le Sage space is filled with minute particles, ultramundane corpuscles, moving rapidly in all directions; hence a single body experiences an impetus on all sides; but if we take two bodies each screens the other and they are *pushed* together. At first sight the impulse due to the impact would seem to be proportional to the effective area whereas according to Newton's law it ought to be proportional to the mass; but when we compare the diameter of a molecule with the distance between molecules, we see that only a small portion of the particles are arrested and that the number arrested is proportional to the number of molecules in the body (the mass).

"The objections to Le Sage's theory are almost too numerous to mention. First and foremost, the enormous speed at which these corpuscles must travel so as not to resist planetary motion involves an enormous supply of energy from a source outside our universe. On this theory the source of gravitation is ultramundane. Again if these corpuscles are elastic there would be no screening action on the part of a body as the corpuscles would carry away their energy in reflection. If the corpuscles are inelastic, bodies ought to increase in size. As the corpuscles transfer their momentum to bodies, they lose kinetic energy, and according to Maxwell the loss sufficient to account for gravitation if converted into heat would keep the body white hot. Sir J. J. Thomson has shown that it is not necessary to suppose the energy is transformed into heat. In place of heat rays he suggests that the particles might give rise to a very penetrating radiation just as the cathode particles are supposed to give rise to short ether-pulse known as Röntgen rays.

"About thirty years ago Zöllner explained gravitation on the assumption that the molecules carry positive and negative charges and the attraction between two unlike charges exceeds the repulsion between like charges. Lorentz, assuming a neutral body to be an assemblage of positive and negative electrons, has used the same hypothesis.

"At Cambridge University during the fall term of 1908, Sir J. J. Thomson gave a course of lectures on "Ether and Matter" and in that course he devoted about three lectures to gravitation. Consider two charged plates. Outside the plates we have opposite effects in the same direction, hence they annul. Between the plates we have opposite effects in opposite directions and the effects are equivalent and hence cumulative. The tension will depend upon the number of lines and the closeness together. Each positive line will increase the tension of a positive line and a negative line will diminish the tension of a positive line. If a positive line increases the tension of a positive line just as much as a negative line decreases it, and if a negative increases the tension of a negative just as much as a positive decreases it, then the resultant tension between the plates will be zero, since there are just as many positive as negative lines. But if the effect (increase) of a positive on a positive is

not the same as a negative on a positive there will be a resultant tension between the plates.

"Now, take an unelectrified body which we consider an assemblage of positive and negative charges. Lines of force will start on the positive charges and terminate on the negative ones, and just as there was a tension between the plates if the effect of a positive on a positive was not the same as a negative on a negative, so there will be a tension around this unelectrified body, if the above is true. Hence by making the assumption that the lines of force from a positive charge are not the same as those from a negative charge, the increase in tension of a positive on a positive is not the same as the decrease of a negative on a positive and we shall have a resulting tension. This might give rise to forces in the body of which the most important is gravitation. Now, electrical attraction depends upon the medium. On this theory should not gravitational attraction depend upon the medium? hesion, might be better understood."

"Thus the phenomenon of gravitation remains a mystery; for so far every hypothesis made seems to have insurmountable difficulties. It seems to have little or nothing in common with various other things of which we have some knowledge, and still remains one of the least understood properties of matter. Probably if we could learn something of the mechanism of gravitation, that attraction between particles which only manifests itself at very small distances (cohesion) might be better understood."

Modern Conceptions of Electricity

The Views of Physicists To-day

A forceful article on this interesting subject is published by Prof. P. Gruner in *Die Umschau.* The author opens his essay with a quotation from Poincaré, the great French mathematician, who possesses probably the most profound, analytical mind of all our contemporary men of science. Poincaré says: "If a scientific theory presumes to teach us what is heat, or what is electricity, or what is life, it is condemned *ipso facto*; all that it is able to give us is a crude image." Prof. Gruner continues, "It is indeed a fundamental truth that the ultimate nature of every object is forever foreclosed from the penetration of our human powers of thought, and if we nevertheless speak of the 'nature' of electricity in this discussion, it must be understood that we are speaking merely of the images which science constructs in order to represent graphically the numerous phenomena of electricity in their relation to other phenomena.

These images have undergone frequent changes in the course of time. From the old point of view, which assumed the existence of imponderable electric fluids, exerting their distant effects instantaneously throughout all space, we have passed over to the so-called electro-magnetic theory of light, which has been so ably developed by Maxwell and brilliantly confirmed by Hertz. According to this point of view the essential electrical processes take place, not in the conductors through which the current passes, but on the contrary, in the so-called insulators. It is in the air, which surrounds all our electric wires, that all those invisible electric and magnetic forces play, whose powerful manifestations are known to all, and which are propagated through space with a measurable velocity, namely, that of light. It was only with the advent of this theory that the phenomena of electric waves could be understood, and that their complete correspondence with ordinary light waves could be definitely established. The ground for that most modern development, wireless telegraphy, was now and now only prepared.

However, useful as this representation of electro magnetic forces spreading out in the ether has been, the time came when it was found insufficient and had to make way, in recent years, to the much more comprehensive point of view of the electron theory developed mainly by Lorentz.

The electron theory knows three types of substances: The electrons, small isolated particles of absolutely invariable electric charge, the so-called elementary charge; their mass may be estimated at about one two-thousandths of a hydrogen atom, their diameter is about one billionth of a millimeter; these electrons are the centers of all electro magnetic forces; they represent the unknown thing which we call electricity. The ether still more mysterious in its nature, represents absolute space, absolutely immovable and invariable, and filling all space uniformly. It plays the rôle of the bearer of all electro magnetic manifestations; in this ether all the forces radiated from the electrons are propagated with the velocity of light according to the classic theory of Hertz and Maxwell. Thirdly, we have the material atoms, the building stones of which the entire universe is reared; they are by nature electrically neutral. These atoms are, however, coupled with electrons in perfectly definite manner, and in this way they also enter into mutual inter-action with the electro magnetic forces in the ether. Thus the infinite variety of electrical phenomena originates.

In insulators, for instance glass, the electrons are bound to the atoms of the glass by elastic forces. If now a ray of light, that is to say, a wave of electric force, enters the glass, the electrons are set in sympathetic vibrations, and from the theoretical investigation of these vibrations the laws of optics can be deduced. If, on the other hand, the glass is intensely heated, the electrons themselves enter into violent motion, and now electro magnetic waves, that is to say, light-rays, proceed from the electrons—in this way the whole mechanism of luminous phenomena is made clear.

In conductors, on the other hand, that is to say, the metals, we think of the electrons as being quite freely movable. They can flit to and fro everywhere between the molecules of the metal, and are hindered in their motion only by their mutual collisions. Every action of an electric force influences the motion of the electrons as a whole, it creates the electric current, and by virtue of the increased kinetic energy of the electrons produces the heat effect of the current.

Lastly, there are bodies, such as iron, in which the electrons circle around the atoms, as the earth revolves about the sun. This rotating motion produces magnetic forces, so that such molecules behave like small magnets, thus furnishing the basis for a theory of magnetism.

This connection between rotating electrons and magnetic forces furnishes an explanation for a very remarkable phenomenon which was observed by Zeemann in 1896, and which has become one of the mainstays of the electron theory. Inasmuch as a luminous metal vapor contains oscillating electrons, a strong magnetic field must needs effect the oscillation, and thus the nature of the light emitted. In point of fact the spectrum of such vapors is actually influenced in a peculiar manner by magnetism, and the effect observed is in exact accordance with the postulates of the theory.

The most remarkable successes of the electron theory have been reaped in the field of the so-called new rays. The cathode rays, which are produced when a very dilute gas is exposed to strong electric discharges, behave precisely as if they were made up of a continuous stream of ejected electrons. Here, therefore, these ultimate atoms of electricity are placed before us in free, so to speak tangible, form. From measurements performed on such rays (and also on the analogous beta rays of radium) the result follows that probably only negative electrons of the very small mass mentioned above exist, and that they flit through space with the unimaginable velocity of some 283,000 kilometers per second, their mass increasing with their velocity. It is impossible to enter here in detail into the far-reaching consequences of this observation, which lays the ax to the very root of Newtonian mechanics, wherein the mass of a body is necessarily supposed constant.

It is impossible to properly estimate the significance of certain problems relating to the electro dynamics and optics of moving bodies, however unimportant such questions might appear at first sight. The great central question on which everything hinges is this: when a body rotates in space, does the ether which permeates this body in all directions, participate in its motion, or does it not, or in other words, are the electric, magnetic and optical phenomena in moving bodies influenced by the absolute motion of such a body, or do they depend purely on the relative motion of the two bodies with regard to one another? The answer to this question has come in a most remarkable shape. As the result of a number of reliable experiments (by Eichenwald, Röntgen and others) it has been found that the Lorentz theory, based on the assumption of an absolutely immovable ether, gives correct results, as opposed to the Hertz-Maxwell theory, which here proves incorrect.

But when the attempt was made to determine whether the motion of the earth around the sun, taking place at the velocity of 30 kilometers per second, has any kind of effect upon experiments performed upon the earth, there was not the slightest influence observable, contrary to the demands of the electron theory.

Two ways stand open to us to solve this contradiction, and both cut deep into our ordinary modes of thought. Either we must assume, that not only the mass of a body, but also its dimensions, are altered purely as the result of motion through space, or we must adopt the standpoint of the theory of relativity, which resolutely finally banishes "absolute" concepts from our natural sciences, and which leads to most astonishing results as regards our conception of time.

However this may be, we may well feel that the inquiry after the "nature" of electricity is far from having reached its goal. Step by step our knowledge is increasing, and daily more precise become the mental pictures by which we are enabled to gather together the infinite variety of a most heterogeneous phenomena into one unified whole.

Photography in Detective Service

It is a well-known fact that the photographic plate is much more sensitive to certain distinctions in color than the human eye. This remarkable property has found extended and important use in the tracking of criminals. Prof. R. A. Reiss has published an account of a large number of examples of most striking character, a brief review of which appears in a recent number of *Die Umschau,* and is cited below:

"A handkerchief which has been washed with soap is to be examined as to any possible traces of blood. The linen appears uniformly white without any stains. A chemical examination in such a case would be quite unavailing, as there is no information at all as to where the stains may be located. A photographic copy of the handkerchief taken through a dark blue light filter shows distinct stains, which are then cut out from the linen and separately tested by a special method which establishes their true character.

"In another case a search through the living apartment of a person suspected of forging 100 franc notes, disclosed the presence of a number of lithographic stones, the surface of which had been freshly scraped and polished. The ordinary methods for bringing out old drawings upon lithographic stones yielded an entirely negative result. It was only by photographing the slab after special chemical treatment, that the pattern of the bank notes was disclosed. Among these, was one which had been engraved no less than twenty years previously.

"At one of the public libraries it was discovered that a copper engraving had been abstracted. The thief had, however, omitted to remove the protecting tissue paper cover. All efforts, aided by the context, to recall the character of the picture, proved fruitless, and the only resource left open was to endeavor to reconstruct by photographic means the vanished picture from any impression which it might have left upon the tissue-paper cover. This task was accomplished with complete success by photographing through a blue filter and reinforcing the contrasts by the successive perforation of positive and negative copies. This resort was rendered possible through the fact that the grease of the printers' ink had been partially absorbed by the tissue paper, and had, by oxidation, imparted to the same a slight yellow coloration quite invisible to the eye. The engraving was later discovered in the thief's possession.

"The examination of a drowned woman by photography disclosed distinct evidence of strangulation, marks which were absolutely invisible to the naked eye. On the basis of this evidence it was subsequently established that the drowned person had been thrown into the water after a previous struggle.

"Among other instances of the use of photography to detect crime or unravel mysteries may be briefly mentioned the discovery of the traces from pencil characters upon paper over which the actual writing paper had lain during the act of writing; the detection of postmarks upon postage stamps chemically treated to renovate them; the development into visible form of previously invisible ink impressions; the detection of fraudulent tampering with sealed mail matter; the regeneration of the text of charred documents, etc."

Long Steel Shaving

W. B. Huff, a machinist, claims to have broken the world's record by making the longest shaving ever produced. While turning down a piece of vanadium steel he cut out a spiral sliver that measured 155 feet in length stretched out on the sidewalk.—*Vanadium Facts.*

Soldiers in the Field Assembling an Aeroplane Which Has Been Brought to the Spot by an Auto-Truck.

Aeroplane Service in the Recent French Maneuvers

The Aviator as a Scout

It is with no small interest that the civilized nations, and especially military circles, have followed the developments of the recent French aeronautic maneuvers. A review of the general course of events is given in the *Zeitschrift für Flugtechnik*, from which the accompanying map and most of the information given below are derived.

The opening date of the maneuvers had originally been set for June 18th, but some delay occurred owing to the unfortunate accident and death of Lieut. Princeteau. Three other victims, Capt. Camine and Lieut. Grailly, and, more recently, Nieuport, complete the list of fatalities to the present day.

Five officers had received instructions to meet at Bethény near Rheims (see the accompanying map), whither they were to repair by air route. Their reunion at this point was effected with complete success as follows:

Capt. Etevé and Lieut. Cheutin rose from St. Cyr on June 22nd at 3:30 A. M. and reached Bethény without a hitch, traveling over Palaiseau, Meaux, Montmiral, Bergères les Vertus, Mourmelon (see the accompanying map). Lieut. Ludmann reached Bethény on June 21st from Douai via St. Quentin. Lieut. Clavenad left Vincennes at 4:25 in the morning on June 22nd, and flying over Lagny, La-Ferté-sous-Jouarre, Chateau-Thierry and Ville, arrived at Bethény at 5:35 A. M.

An episode which occurred during Lieut. Ludmann's flight caused him and his passenger some minutes of extreme suspense. While flying in somewhat gusty weather at a height of about 1,800 feet over Cambrai, Deville observed that a nut had become loosened on the motor and that the magneto was not functioning properly. Lieut. Ludmann, whom Deville informed of the trouble, tightened the nut as they went along, in the hope that they would reach Rheims in safety. The nut, however, kept loosening, and the two airmen were placed in a precarious position, and made a landing as quickly as possible. Deville, who had been placed under severe strain during these occurrences, jotted down in his note book:

"In case we should fall, let it be known that the accident was caused by the loosening of a nut in the motor and the failure of the magneto, and that there was no fault of any kind to be laid to the manipulation of the machine."

All the machines were fitted with full field equipment as in the time of war, each pilot carrying with him altitude measuring instruments and compass, besides tools and substitute parts. The reserve parts were simply packed in a sack and tied to the chassis. Each machine also carried a special velocity meter, designed by Capt. Etevé and Sergt. Cayla. By the use of this instrument it is possible to maintain a constant velocity. Any sudden descent, owing to the slowing down of the motor, is thus prevented, and a high grade of security insured.

The plan of war laid out by Col. Hirschauer was as follows: A. A blue army is advancing toward Bruges, its cavalry detachments being reported as moving toward Lille and Hazebrouck. Apparently the intention is to advance upon Paris. Further detachments of cavalry have been sighted at Valenciennes.

A red army with aerial reconnoitering corps is occupying the Champagne. The problem set for the aviation corps of the red army was to reconnoiter along the line from Arras to Roubaix; and further, to gather information as to the flanks of the opposing army, and to determine whether beyond the cavalry reported there were any considerable bodies of troops on the field.

B. A blue army is stationed along the line Lille-Calais; cavalry is reported in the direction of Arras. It is proceeding toward Paris in order to relieve it.

Map of the Territory Covered by the French Aeronautic Maneuvers.

The blue army disposes over an aerial reconnoitering corps; a red army is reported in Normandy near Rouen upon the left bank of the Seine.

A second red army holds the line Beauvais-Creil, its cavalry being reported from the Somme. The problems given to the aviators for solution were as follows:

1. To reconnoiter the territory of Picardie from the line Calais-Douai up to the bank of the Somme.

2. From the Somme to determine the distribution and force of the armies reported from Normandy, and from the region between Beauvais and Creil.

These instructions were carried out as follows:

Capt. Etevé rose from Bethény at 3:55 A. M., reconnoitered along the line Laon-St. Quentin-Cambrai-Douai and the region west of this. He landed a few minutes after six in Douai after having finished his task. Lieut. Cheutin left Rheims at 3:10 in the morning, flew along the line Camp de Sissones-St. Quentin-Cambrai-Douai, and reconnoitered the field lying east of this line. He arrived at Douai at 5:30. Lieut. Ludmann accomplished his task without special incident.

Lieut. Clavenad flew from Rheims over Mezières. Meeting with a high wind, he rose to 3,600 feet, covered a distance of 140 miles and nearly reached Douai. When within only about a mile of his destination, however, he ran short of gasoline, and was forced to land in a marsh, whence he had his aeroplane transported to the shed. Most of this work was carried out in excellent weather and the pilots reported that at a height of 2,500 feet the view extended over nearly twenty miles.

At 5 o'clock in the morning, however, the weather turned, and all the aviators declared that they had never flown in such high wind. It is therefore particularly gratifying that in spite of these untoward circumstances all the tasks undertaken were successfully performed.

It is not necessary to give in detail the complete itinerary of the several flights made in the course of the maneuvers by the aviators. It will suffice to mention that about the 20th of June the two Maurice-Farman biplanes alone had covered a distance of 400 miles each. By June 30th the record for distance flown was held by Capt. Etève, who could boast of 600 miles to his credit.

The maneuvers were interrupted for a time owing to regional epizootics, but were resumed on September 5th. According to *Flight*, in all twenty-nine machines participated. For the transportation of the aeroplanes special automobile haulers were provided. According to a description given in *L'Illustration* the tractor is capable of covering twenty-four to thirty miles an

Captain Bellanger Reconnoitering in His Aeroplane Discovers a Village Occupied by the Enemy.

hour and will accommodate the crew belonging to the aeroplane, comprising six men in all. Further, there is on board a box containing two substitute propellers; there is also a tent and all its accessories; in addition to this a variety of substitute parts, tools and utensils for constant use, a store of gasoline and oil sufficient for 360 miles, a stretcher and medical chest.

By these trucks the aeroplanes are hauled from place to place over the highways, whenever their movements are not made by the aerial route. No special shelter for the aeroplanes is provided, the machines passing the night in the open air.

One result of the recent maneuvers is to bring out more clearly than ever before the principal functions which the aeroplane is destined to fulfill. We are by now accustomed to attaching but little importance to the aeroplane as an instrument of artillery, for throwing bombs, etc. Its use for carrying messages, also, is not likely to prove of such very great importance, now that we have at our disposal a variety of highly developed and efficient systems of signaling by wireless and other methods. The great utility of the aeroplane—and in this field the possibilities seem almost unlimited—lies in its remarkable adaptability for reconnoitering purposes.

This year's maneuvers may be regarded as the first in which true war conditions were approached so closely as is possible in time of peace. The maneuvers of last year were too much of a new departure to allow proper attention being paid to this feature, since a great part of the attention of the military staff had to be given to the launching of an entirely new enterprise.

Taking the maneuvers as a whole, the aviation corps of the French army has made a most remarkable performance. Occasional extraordinary feats have been on record for some time past, but the thing which attracts our attention about the recent exploits is the remarkably high average attained. In the course of a few days the aviators have covered an aggregate distance of 2,800 miles, and, without suffering any breakage worth mentioning, all the machines have returned without accident and without loss of life after carrying out with complete success the problems set them.

The military value of flying machines lies in their use for reconnoitering. Their good services in this field will often render futile the enemy's tactics. According to Colonel Bernard, two batteries with one aeroplane are more serviceable than three batteries without aeroplanes. The aeroplane has reached a stage at which it satisfies most requirements. It only remains to train a competent staff of aviators, and in this respect France is still far ahead of all other nations.

Mutations Among Shrimps

When DeVries announced his theory of evolution through mutation, his demonstrations were widely accepted among the botanists; the zoologists were inclined to be skeptical, many accepting the facts put forth, but assuming that the processes described could not take place in the animal kingdom. During the past decade numerous observations in various parts of the world have shown the "saltations" to occur among animals as well as among plants. The latest contribution to this problem is from Prof. E. L. Bouvier, of the Museum of Natural History in Paris.

Among the shrimps of the family Atyideæ there are three distinct genera that form as it were a linear series, in the gradation of certain of their characters. In the genus *Caridinia* the claws or pincers are of the type found in crayfish or lobsters—that is, there is a rather broad "palm" with a small "thumb." The front pair of pincers are set into a hollow at the end of the so-called "wrist" joint of the appendage; the second pair of appendages does not show this hollow. The body of the animal is slender. In the genus *Ortmannia* the pincers are similar to those in *Caridinia*, but the cleft between the "thumb" and the "palm" extends down farther; and the second pair of pincers are set in hollows as well as the first. The body of the animal is distinctly broader than in the first genus. In the genus *Atya* the pincers are split to the very bottom, and both pairs are set in deep cavities at the ends of short "wrist-joints." The body is medium to broad, sometimes very broad in comparison to the length. There are also graded differences with respect to the lengths of hairs on the claws and other characters; but those mentioned are the most striking. The transition in this branch of the family is thus seen to be from a slender body to a broad one, and from distinct sets of claws to similar ones, of a type differing from the ancestral form.

Now a number of years ago Prof. Bouveri observed the sudden appearance in cultures of *Caridinia apiocheles*, of individuals of the type *Ortmannia*. During this past year he has found two species of *Ortmannia* giving rise to forms of the type *Atya*. These two species are *Ortmannia Alluaudi* Bouveri, occurring in the islands of the Indian and Pacific oceans, and *Ortmannia Henshawi* Rathbun, which seems to be restricted to the Sandwich Islands. These two forms are quite distinct, and *both* have produced mutations into *Atya*.

One female *Ortmannia* has given birth to individuals of the Ortmannia type and also to some of the Atya type. These two sets of shrimps differed considerably in size, the mutations being much larger than the parent form. After their appearance the mutations develop normally in the manner of the Atya type.

These observations differ from those generally described in one important particular. The mutations of DeVries, for example, have resulted in new forms that constituted varieties, races or "elementary species" of the original group. In the mutations of Bouveri, however, each new form corresponds to a distinct genus that is in the direction of the group's evolution. For this reason Bouveri applies the term "evolutive mutations" to these phenomena. He suggests that when a type of organisms has reached a certain stage of maturity, it may suddenly jump to a higher type. From the observations on discontinuous variations so far made, he makes two groups, those in which the variations are slight, and those in which they are well marked. His distinction is based not upon the number of characters that are modified, but upon the relation of the new individuals or "sports" to the group from which they arise. If they merely modify the physiognomy of the species, as in the case of the evening primroses of DeVries, he calls them "slight variations"—or even if they lead to the establishment of new species, as in the case of a number of organisms showing distinct forms on the two sides of the Isthmus of Panama; or, finally, if they lead to the formation of continuous, intergrading chains of species varying in the same direction to generic forms, as in the case of different species of elephant connected with the Mastodon through species of the genus *Stegodon*. If, on the other hand, the "sport" establishes at one stroke a new organic type, differing from the parental type as a new genus, we have so-called "evolutive mutation."

The Great Star Map.—VII*

Some Incidents of the Work.—Continued

By H. H. Turner, DSc., D. C. L., F. R. S., Savilian Prof. of Astronomy in the University of Oxford

Concluded from Supplement No. 1866, page 227

It should perhaps be remarked here that the *relative* distances of all the planets from the sun and from one another are known with great precision from the times which they take to describe their revolutions round the sun; so that when any one of them has been determined, we can obtain any other we please by a simple rule-of-three sum. Or, to put the matter in another way, we can make an accurate map of our solar system, being in doubt only about the scale of miles which usually accompanies such a map. Any single distance on the map being known, we could construct this scale and so find all the others. Hence it did not much matter whether we determined the distance of Mars or of Venus or of any other planet which might offer greater advantages than they; the new discovery of Eros offered just such greatly increased advantages. The opportunity is, however, not open always but only at certain times and seasons. One particularly tempting opportunity had been unfortunately lost in 1894 owing to our ignorance of the planet's existence. But it was seen that another opportunity was coming in 1901, not so favorable as that of 1894 but still well worthy our attention. It may be added that the next good chance will not come till 1931, so that it is easy to understand the anxiety of astronomers to take advantage of the occasion of January, 1901. They were, however, taken at a disadvantage by the comparatively short notice. There was no time to think of preparing special instruments; prudence suggested utilizing such instruments as were already in good working order, and especially the battery of photographic telescopes engaged in making the Great Star Map. It needed a good reason to justify this diversion of their activities from the great work, which was alone sufficient to occupy their undivided attention, but the reason which had presented itself so suddenly was felt to be good enough. At the meeting at Paris, in 1900, of the committee charged with the work on the map, the President (M. Loewy) proposed that this digression should be made; and the proposal was unanimously adopted.

Accordingly for some months during the winter 1900-1, most of the telescopes were withdrawn from the work on the map and were turned on the little planet Eros. The chief aim of the programme was to take photographs as soon as possible after sunset and as late as possible before sunrise; for on these occasions the telescope would be as nearly as possible on opposite sides of the earth. A few sentences ago we compared a pair of eyes to a pair of telescopes pointed at the same object from opposite sides of the earth; but a single telescope may be made to serve the purpose of a pair, since the rotation of the earth carries it round during the night from one side to the other; and this will explain the sunset and sunrise exposures to the planet Eros. In this way many hundreds of such photographs were obtained.

The next thing to do was to measure all these photographs accurately, in order to determine the place of the tiny planet among the stars. This place was of course changing continually, owing to the movement of the planet round the sun and indeed owing to a similar movement of the earth also. But it was possible to devise methods of allowing for this movement and correcting the measures for it. There would remain the displacement due to "parallax," that is to say, to the finite distance of the planet which it was required to measure. The greatest amount of such displacement was about 23 seconds—about one-hundredth part of the moon's apparent diameter; which it was desired to measure if possible to the thousandth part of itself. Hence the measurement required a new order of accuracy; the apparatus already in use for the Great Star Map needed modification in essential details for this new enterprise. Moreover it is a familiar fact in scientific work that, when we proceed to the next decimal place, we always encounter a number of unforeseen difficulties of all kinds; and the measurement of the Eros plates was no exception to this rule. Some of these difficulties arose in the course of the measurement at the separate observatories and were vanquished as they arose. Particularly was this the case at our national observatory at Greenwich, where a complete determination of the distance of the planet was made from the Greenwich plates alone, without help from those of any other observatory and with very satisfactory results. But to get the full advantage from all the many photographs taken it was necessary to co-ordinate all the measures made at the different observatories, which brought to light a new crop of difficulties. It is to the lasting credit of Mr. A. R. Hinks, of the Cambridge University Observatory, that he undertook, as a volunteer but with the full approval of the President of the Committee charged with the work, to collect and co-ordinate all the results. The labor was very heavy and has occupied a large part of his working time during ten years. The difficulties which cropped up were new at every turn and great ingenuity was called for in overcoming them.

One such difficulty may be mentioned in illustration. It has been remarked above that, when stars are observed visually, there is apt to be a "magnitude equation," i. e., a difference between the records for bright and faint stars but that the introduction of the photograph seemed to offer a check on these errors, being itself free from them. On this assumption Mr. Hinks proceeded to treat the measures of the Eros plates; but on comparing the measures at different observatories, he found between them just such differences as affect old visual observations under the head of magnitude equation. The differences were not so large perhaps but were nevertheless sensible. It may occur to the reader to inquire whether the differences arose in the measurements of the plates, which were of course made visually; but such a possibility was eliminated by the method of measuring each plate twice over, as has been explained in a previous article, the plate being turned completely round for the second set of measures; any magnitude equation would affect the two sets of measures in reverse directions and could thus be both detected and eliminated. This alternative being ruled out, it followed that the error must be in the plates themselves and it was a very disturbing discovery to find that we had not, as had been hoped, freed ourselves from such a kind of error by the introduction of photography.

Some comfort was forthcoming from the further discovery that many of the plates *were* sensibly free from this error, but these only increased the puzzle. What could be influencing those which showed unmistakable traces of it? Ultimately the cause was found in a faulty lens or rather in the faulty arrangement of the pair of lenses which go to make up the object-glass of a telescope. We have now realized that this arrangement must be carefully made and that faults render us liable to this old trouble; but it also seems probable that with care on the part of the instrument maker, the trouble can be avoided or, at any rate, rendered conveniently small. It is easy to sum up in a few words in this way the net result of the investigation; but the investigation itself was a long and tedious one and is perhaps even yet scarcely completed. It was faced, along with many others, with great courage and patience, with the ultimate result that, in the spring of 1909, Mr. Hinks was able to announce to the Paris Academy of Sciences a most satisfactory result for the distance of the planet and, by implication, for that of the sun and of the other members of the solar system.

He was also able to add a value for the mass of the moon. It may seem strange that this altogether different measurement of mass is to be deduced from the figures which give us a measure of length; but the fact is that we measure the mass of the moon by noting a certain length, namely, the distance by which it pulls the earth from side to side as it waltzes round with it. The earth and the moon may be compared to a pair of partners dancing round a ballroom; if they were of equal size, they would swing equally to right and left of their average path; but the moon is much the smaller and only pulls the earth a very little way from side to side. Nevertheless the oscillation is perceptible and it alters the aspect of the planet Eros in the same kind of way as the oscillation of a telescope from one side of the earth to the other. Indeed the two oscillations are combined together in the measures and we only separate them by the fortunate circumstances that one takes place in a day and the other in a month.

Before leaving the conclusion of this great problem of the planetary distances, which has come down to us through the ages, a word or two may be devoted to its history. The Greeks made attempts to determine the sun's distance but they were very crude: for example Aristarchus of Samos made it only nineteen times the distance of the moon, or about 4,500,000 miles; and it was long before anything like the true value (about 93,000,000) was arrived at. In the middle of the nineteenth century the margin of doubt was some millions of miles, but it was expected that the transits of Venus in 1874 and 1882 would reduce this margin within narrow limits. The observations made at these famous transits were, however, very disappointing, and even before the second of them was due, some astronomers had already turned to other methods for finding the sun's distance, especially the observation of the planet Mars and later of one or other of the small planets. The best determination of this kind, previous to the Eros determination, was that by Sir David Gill at the Cape of Good Hope about 1889, who obtained a result closely like that at which Mr. Hinks arrived twenty years later. But there are other measurements which bear an interesting relation to this direct measure of distance, especially those which compare the velocity of the earth in its revolution round the sun with the velocity of light. This comparison can be made in two entirely independent ways which take account of two entirely independent movements of a star, one directly in the line of sight and the other at right angles to it. Until the invention of the spectroscope, the latter was the only movement of a star, real or apparent, of which we could take account. It was discovered by Bradley early in the eighteenth century that by noting the apparent changes in direction of any star, we could find the ratio of the earth's velocity to that of light; for the aberration, as he called it, was due to the relation of these two velocities. Hence if we can find the velocity of light by independent means, we can deduce the velocity of the earth and from this the length of its path during one year; from this the radius of its orbit can be found, which is the quantity we seek. Now the velocity of light has been successfully measured by terrestrial experiments with sufficient accuracy, so that the distance of the sun can be deduced from measures of aberration. But curiously enough the value so found does not quite accord with that given by Sir David Gill and confirmed by Mr. Hinks. The discrepancy has been rendered more remarkable within the last year or two by the successful measurement of aberration by the other method, using the spectroscope, which enables us to measure the velocity of a star in the line of sight. The velocity thus found is partly that of the star and partly that of our earth; in many cases (though not in all) we may consider that of the star as steady but that of the earth varies during the year, being sometimes toward a particular star and sometimes directly away from it. By comparing the observations on these two occasions, we can eliminate the steady velocity of the star and deduce the velocity of the earth alone, from which we get, as before, the distance of the sun.

Now measures made recently on this plan have given a result in satisfactory accordance with that of Gill and Hinks, and have thus rendered the isolation of the other result from aberration the more remarkable. There are some who think that the discrepancy will ultimately lead us to the discovery of some new phenomenon about which we are at present entirely in the dark. To illustrate what is in their minds we may recall that Lord Rayleigh was led to the discovery of argon by paying attention to minute discrepancies in the values he obtained for the density of nitrogen from different sources; and not only was the discovery of argon important in itself but it has led to others of vast importance. So that all these may be said to have originated in the study of a minute discrepancy between two measures of what purported to be the same quantity. Is it possible that the future may have in store for us similar weighty consequences, traceable to the study of this discrepancy in the measure of the sun's distance?

But astronomers know only too well how easily such discrepancies may turn out to be due to some source of error that has been overlooked. Their science is concerned, perhaps more than any other science, with minute measurements which a minute error will nullify or disturb; and they must be continually ready to see the edifices which they have spent some labor in building tumble down like a house of cards owing to some tiny flaw in the foundations. An instance of this occurred as a by-product of the Oxford measures and will serve as an illustration. In the year 1902

* Reprinted from *Science Progress*.

Sir David Gill made the suggestion that the brighter stars were apparently rotating as a whole with respect to the fainter stars as a whole, basing it upon many thousands of observations made at two epochs about half a century apart. If the whole universe was rotating together we might not be able to perceive it. Many familiar tests would fail just as they failed to reveal the rotation of the earth to our ancestors. Should we have yet learned this great fact if our sky had been permanently cloudy so that we never saw the stars? We might have suspected it from the recurrence of daylight; and we might have actually inferred it if we could have surveyed the earth in some way and found its equatorial bulge, which we might have rightly ascribed to the effects of rotation. Similarly we might be able to infer the rotation of the whole universe of stars if we can be sure of its equatorial bulge of which the Milky Way is a possible manifestation. That brilliant thinker, Henri Poincaré, has made a rough estimate of a superior limit to such a rotation in his book "Science et Méthode" (p. 285), finding a second arc in 3,000 years, or a complete rotation in four thousand million years, which is really not very long considering that geologists would like to take it all for the life of our earth itself.

But Sir David Gill was not dealing with this general rotation of all the stars together: he thought he had detected a relative rotation of the bright stars and it seemed possible that some evidence might be gathered from the photographic measures in the following way. Of the stars whose places had been determined at Cambridge about 1880, some had been photographed at Oxford in 1892, others (say) in 1902. Assuming that there was in reality a relative drift of the bright stars as suggested, the plates of 1892 ought to show ten years of it when compared with the Cambridge observations of 1882, while those of 1902 would show twenty years of it. By simple subtraction we could get ten years of the drift. The subtraction is rendered necessary by the existence of the "magnitude equation" already noticed at the beginning of this article, which would affect both determinations of drift and prevent the drift from being identified from either source by itself, though it could be found from their difference if it could be rightly assumed that the effect of magnitude equation was the same in both cases. The experiment was accordingly tried, though scarcely under such favorable conditions as sketched above; with the result that a drift of the bright stars seemed to emerge of about the magnitude assigned by Sir David Gill *but in the contrary direction* (*Mon. Not. R.A.S.* lxiii. p. 56). Attempts were made to find a reason for the discrepancy but on extending the inquiry to movements in declination (*Mon. Not.* lxiv. p. 3), proper confirmation was not forthcoming, and it was suspected that there was some unknown source of error (*loc. cit.* p. 18). At that time it had not been suspected that magnitude equation could occur in photographic measures; but when subsequently Mr. Hinks came across a gross case of it in the work on the Eros photographs, as above mentioned, it was seen that the unknown source of error had probably been detected and the significance of the measures was thus destroyed (see *Mon. Not.* lxv. p. 55).

But if in this instance we failed to obtain what was searched for with much labor, on another occasion we made a considerable find without looking for it at all. The history of our Oxford portion of the map was made remarkable by the quite unexpected discovery of a New Star. It would be possible to institute a regular search for new objects by the use of star maps, comparing one plate with another taken on a different date; again, if the spectra of the stars are photographed as at the Harvard Observatory, then a new star might reveal itself on inspection of a single plate by the peculiarity of its spectrum. But neither of these methods was in the least degree in our minds in the course of the Oxford work on the map and the discovery was entirely accidental, as will be seen from the following account.

At the beginning of the year 1903 we were within sight of the completion of the measures and hoped to reach it before the end of the year. For several reasons the actual completion was ultimately delayed beyond this date but that is a point which does not concern us just now. In the hope of completing the measures before the end of 1903, we were making great efforts to secure all the plates which had not yet been taken.

If the favorable season for taking a particular plate before it "runs into daylight" is lost, we may have to wait nearly a year before another opportunity recurs; so that it was important to obtain all the January plates in January, 1903, not leaving any gaps for January, 1904. To expedite matters, when there came a specially fine night or two, a large number of plates were taken, which were set aside for development until the good weather was gone. In England we have learned to prize these exceptional nights; and it may be remarked in passing that we occasionally get nights as good as anywhere in the world, though the occasions are not so frequent as in California, for instance. All too soon the indifferent weather came, the plates were developed and, to our great disappointment, it was found that they were not satisfactory. There had been an unfortunate failure in sensitiveness of the films, which is apparently liable to happen in the manufacture of extremely rapid plates; when straining at the limit of sensitiveness some very slight cause may produce a notable failure to reach that limit. The disappointment was the greater because it was practically the first of the kind; throughout the whole work the plates had been uniformly satisfactory, in spite of the risks just mentioned, otherwise we might perhaps have been on our guard against the shortcoming. There was, however, nothing for it but to take the photographs again; and if there had been need for special exertion before, this need was now much greater in consequence of the diminished time at disposal. No very great surprise therefore was felt when one or two of the new plates were found to be faulty from a different reason. There was no further failure in sensitiveness, for the plate-makers were most sympathetic about our disappointment and immediately furnished an excellent batch of new plates. The fault was now that the telescope had not been accurately pointed to the right region of the sky—a kind of mistake which might reasonably be ascribed to the strain of working against time. But it is a good rule in astronomical work (probably also in other walks of life) to get to the bottom of any mistake if possible and so it proved in this instance. On comparing one of the wrongly set plates with another of the same region, it was seen that it contained a strange object which ultimately proved to be a new star. The mistake had arisen because it is customary to select as guiding star the brightest in the neighborhood (as being most easily identified) and the new star had blazed up so as to be brighter than any other near it; so that Mr. Bellamy had accepted it without question as the one to which he was to point his guiding telescope during the taking of the photograph.

We could not be sure for some little time of the nature of this object. It might be a planet or a veritable star. The first alternative was soon disposed of because it is easy to look up the places of the planets which could be bright enough; and, moreover, a planet would probably have betrayed itself by a slight movement between the three exposures given to each plate in the making of the map. The second alternative occupied attention rather longer. There are many stars scattered over the sky whose brightness varies considerably, so that they might at one time show an emphatic image on one plate and at another time be too faint to affect the plate at all. Many of these are well known and can be found in catalogues already published; others are being discovered year by year and no doubt we are still unaware of many to be discovered in the future. During the afternoon the lists were searched without finding any mention of a variable in that particular neighborhood; and when in the evening the star was found to be still shining in the exact place of the photograph, telegrams were sent to other observers inviting their attention to it as probably a new star. Any remaining doubts were dispelled by the spectroscopic observations and Nova Geminorum took its place as No. 18 in the list of Novæ which had been discovered in the history of astronomy.

Readers of the daily press will probably have seen recently an announcement of a similar discovery by the Rev. T. E. Espin, of Darlington, which is No. 22 in this list; for during the past autumn no less than three special objects were discovered at the Harvard Observatory from the examination of photographic plates. The total number is, however, still not large, though from the facts that up to the year 1884 only eight had been recorded and that the other sixteen have all been found in the last quarter of a century, we may infer that the rarity is partly due to our own lack of vigilance, and that the few discoveries recorded would probably have been supplemented by many others had a more systematic watch been kept.

We are at present not very well informed as to the nature of the celestial event which is represented by the appearance of a new star. A few things about it we know. In the first place the event is a sudden one, the light of the star increasing enormously within a day or two by something like twelve magnitudes—that is to say, in a ratio of about 1 to 80,000—then the light slowly diminishes—slowly but not steadily; there are fluctuations in the course of the diminution and these fluctuations were specially noticeable in the case of the new star of 1901—in Perseus. Sir Robert Ball gave us, at the Royal Astronomical Society, an amusing account of his experiences at the time when the fluctuations were such as would cause the star first to disappear to the naked eye and then to reappear again. He had taken a party of visitors into the open to show them the new star, only to find that it had disappeared; on the next night he took out another party to show them the disappearance and, as though to spite him, it had reappeared again. But these were only temporary vagaries, as the star was soon permanently lost to our sight and then even to telescopes of moderate power. It still remains, however, as a very faint object in large telescopes.

Another incident in the history of this particular new star may be noticed, for it seems to tell us something about the origin of such objects. When the light had become very faint, so that photographs of the region were necessarily taken with long exposures, there was found to be a faint nebulous light surrounding the star and successive photographs showed that this nebulous appearance was expanding in all directions, just as though there had been an explosion and the fragments were still flying outward. The phenomenon aroused the greatest possible interest, for a rapid change—that is to say, any change which is perceptible in a few weeks—is almost unprecedented in the case of the stars and could have only one of two explanations; either the star is specially close to us so that the changes appear larger than usual or, if the star be at a distance similar to those of other stars, the changes themselves must be on a gigantic scale. It was soon seen that the latter was the right alternative and it was inferred that the velocities of the flying fragments must be comparable with the velocity of light (nearly 200,000 miles a second).

Now there is an interesting physical question, whether it is possible for gross matter to move through the ether with a velocity greater than or even as great as that of light. At first the hope was entertained that we were going to get some information on this interesting question but a more practical alternative was suggested, viz., that the velocity exhibited was not that of matter but actually that of light itself. The observed facts would be explained if the nebula had been in existence previously but had been without illumination, so that we were unaware of it; just as we are unaware of an object in a dark room until a flash of lightning illuminates the room. In such a case the illumination appears to be instantaneous, but since light does actually take time to travel, it cannot be quite instantaneous, which we should realize were the room billions of miles in size. The room taken up by a nebula is of this size and the flare-up of the new star therefore illuminated it gradually, beginning with the nearer portions and spreading to those more distant as time went on. This explanation of the fact was confirmed by a remarkable experiment. The light of the nebula was analyzed by means of the spectroscope and found to correspond with that of the original flare. A spectrum is, after all, only a glorified name for a color; we may represent the facts in simple language by substituting names of colors. The events would then be as follows: the star rose to its greatest brightness with a blue light, which afterward turned to red and remained red as the light died away. Now the light of the nebula was not found to be red, as it would have been if it belonged to the star in its later stages, but was found to be blue, and must therefore owe its existence to the blue flare some months previous, which had taken that time to traverse the huge distances separating the outlying portions from the center. If this be so, we may further suspect the nebula of having been concerned in some way in the original outburst. It seems plausible that some kind of encounter between the previously faint star and the previously faint nebula should have resulted in a great development of heat and light which sent the news to us.

It would be interesting to get confirmation of this possibility in other cases, but unfortunately the conditions are not always so favorable. Nova Persei blazed up brighter than the first magnitude stars, and though there have been new stars even brighter than these (such as that of 1572 which was even visible in the daytime), most of those we now find are much less bright; so that if they are accompanied by the illumination of nebulæ our resources are not able to photograph them.

Here we must conclude this brief review of a quarter of a century's work on the Great Star Map and other matters related to it. The work is far from concluded as a whole, though two portions of it have been so far finished as to enable us to form some idea of the completed whole. But the attainment of any particular stage is after all only an incident in a journey, for in a very real sense the map will never be finished. Our real concern is not with the state of the heavens at any particular moment with the changes which may be discerned by comparing one epoch with another; accordingly when we have mapped out any region satisfactorily we are not at the end but at the beginning. Our real work consists in watching the development of change, which may be slow to declare itself to our brief lives but will persist relentlessly during eternity.

The Distorting Mirror in Art*

Vagaries of Great Painters

By P. G. Konody

FEW observant visitors to the National Gallery can have failed to notice in the center of the foreground of Holbein's famous picture, "The Ambassadors," a curious fish-shaped object, which, on closer inspection, and especially when viewed at an angle from the right-hand side, explains itself as a Death's head, such as its reflection might appear in a curved mirror. The exact significance of this apparently freakish conceit has never been satisfactorily explained.

That there is some symbolical meaning in this skull, as well as in the celestial and terrestrial globes, the lute, the open hymn book, the scientific instruments, and the many other accessories, cannot be seriously doubted, nor can the thought be entertained for a moment that the fish-shape formed by the distorted skull with its attendant shadow is due to accident or to a mere whim on the part of the artist. This puzzling feature cannot be due either to that love of exact representation of a thing seen which is to a certain extent at the basis of the slightly distorted reflection of the interior in the convex mirror of Jan Van Eyck's portrait group of Jan Arnolfini and his wife at the National Gallery, or to the freakish turn of mind that is responsible for the extraordinary distorted portrait of Edward VI., by an unknown Flemish artist, at the National Portrait Gallery. This portrait can be seen through a circular aperture in a screen fixed to the side of the frame, when it assumes the normal proportions of a circular miniature portrait. It bears the inscription ÆTATIS . SVÆ. 9 and AN° DNI 1546, and was formerly in the collection of King Charles I., at the dispersal of which in 1650 it was sold for $10. As far back as the year 1598 it was described as a curiosity by Paul Hentzner, a German, who in that year saw it in Whitehall Palace. There can be no doubt that this "painting in perspective" was copied, with the aid of a distorting mirror, from the Holbeinesque panel portrait of Edward VI. at the National Portroit Gallery, or from an unknown original which may have served as model for both.

A curved miror was probably also used by Holbein for the painting of the mysterious skull in "The Ambassadors." That it was the artist's deliberate intention to give it the shape of a fish may be gathered from the fact that the shadow, so essential for creating the desired illusion, falls in a direction other than the cast shadows in the rest of the picture. This fish-shape is already referred to in the catalogue of the Beaujon Sale, on April 25th, 1787, where the painting is described as follows:

"16 bis. Another picture 4 feet and a half" (an obvious mistake; it should read 8½) "or thereabouts, in height, by about 8 feet in width.

"It represents two ambassadors (MM. de Selve and d'Avaux), the one, Ambassador at Venice, and the other, in the northern countries, in the costume of the nations to which they were sent, and with the attributes of the arts which they loved. There is also to be seen a Death's head in perspective, from the left corner of the picture, which from the front resembles a large fish. This picture is by the same Holbein, but it is not dated."

The "Painting in Perspective" as Seen Through a Hole at the Side of the Frame.

Reproduced from the *Illustrated London News*

Holbein's "Ambassadors" With the Mysterious Skull in the Foreground.

FREAKS IN ART

That this description of the two personages portrayed could not be correct becomes clear when it is remembered that D'Avaux died a full century after De Selve. Mr. W. F. Dickes, in an exhaustive monograph, entitled "Holbein's Ambassadors Unriddled," applied much ingenuity to proving that the picture was painted to commemorate the Nuremberg Treaty of 1532, whereby Roman Catholic and Protestant princes were induced to lay aside their quarrels and march against the Turkish host; and that the two personages are none other than the brothers Otto Henry and Philipp, of Neuburg, Counts Palatine of the Rhine. Mr. Dickes accounts satisfactorily for every single detail of the puzzling composition, and devotes several pages to the skull (which is repeated as a medallion attached to the hat of the figure on the left) and to the extraordinary fish-shape. The fish was the recognized emblem of Bavaria, so that its introduction in so conspicuous a place might well be connected with the portraiture of the Counts Palatine. Moreover, in an astrological booklet published at Nuremberg after Philipp's death, "the events of Philipp's life are correctly told in Astrolabese, under the sign of Sagittarius, and we read: 'Das Haus seins Vaters ist der Visch' ('The house of his father is the fish')."

That the fish-shaped skull should point straight at one of the brothers, while the other brother wears the same emblem in his hat, is accounted for by the theory that the device was adopted by the family in commemoration of an historical event connected with their ancestress, Queen Adelaide, whose first husband, King Lothair, was murdered in 950 by Berengar, the avenger being Adelaide's second husband, Otto the Great. Mr. Dickes, in support of his argument, reproduces an engraving of "La Giustizia di Ottone il Grande," by Primaticcio, in which Queen Adelaide is seen handing her murdered husband's skull to Otto the Great.

Mr. Dickes's learned arguments did not convince Miss Mary F. S. Hervey, who replied to them in an even more bulky volume, "Holbein's 'Ambassadors,' the Picture and the Men," in which she identifies the two personages as Jean de Dinteville, Ambassador from France to England in 1533, the year when the picture was painted, and his friend, Georges de Selve. Her explanation of the Death's head is not as convincing as Mr. Dickes's; but a recent discovery has proved in incontrovertible fashion that Miss Hervey was right in her conjecture as to the identity of the "Ambassadors." According to Miss Hervey, Dinteville had made acquaintance in England with Holbein's "Dance of Death" series, and had adopted the skull as his personal badge or device. "He was often ill. The vision of Death hovered constantly before his eyes. . . . Under such circumstances the choice of the 'Arms of Death' for his device seems but a natural outcome of his frame of mind." For the fish-shape, Miss Hervey does not offer an explanation.

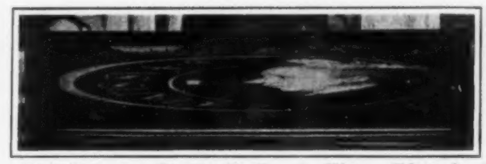
In the April number of the *Burlington Magazine*, Miss Hervey, assisted by Mr. R. Martin-Holland, devotes a long article to a picture by a forgotten French painter, Felix Chrétien, which was sold at Christie's in February, 1910, attributed to Holbein and described as "Moses and Aaron before

* Reprinted from *The Illustrated London News*.

This Photograph Shows the Skull As It Appears to Any One Looking Along the Picture from the Right Hand Side.

Pharaoh." On closely examining this picture, Miss Hervey discovered on the hems of the garments of some of the figures the names of Jean de Dinteville and of two of the Ambassador's brothers. The likeness of this Jean de Dinteville to the personage depicted by Holbein in "The Ambassadors" is a strong point in favor of Miss Hervey's theory; but there is stronger evidence which, strangely enough, seems to

Undoubtedly Symbolic—But of What? The Distorted Skull Assumes a More Natural Shape When Photographed at a Certain Angle.

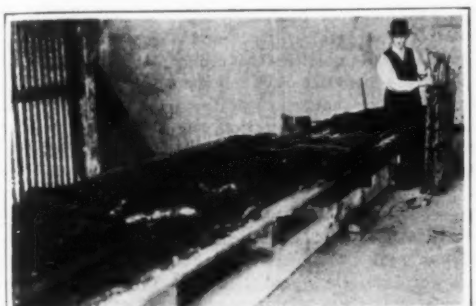


"Painting in Perspective" of King Edward VI as it Appears to Normal View.

have escaped Miss Hervey's attention. The picture sold at Christie's last year is actually the companion to Holbein's "Ambassadors." It is the No. 16 of the Beaujon Sale catalogue, sold, together with the Holbein (No. 16 *bis*), for 602 francs, and was described.

"Netherlandish School. Hans Holbein.

"16. The Court of Francis II., and of the principal lords of that time, with the attributes of Moses and Aaron presenting themselves to the King of Egypt, who is Francis II. himself; their names are written in the different outlines of their robes."



One Side of the Craft and a Stump of the Mast.

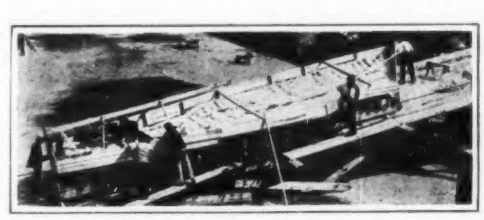
A Roman Boat Unearthed in England

A Relic of the Past

The Boat, Packed for Removal to the Museum at Kensington Palace.

The normal span of human memory covers a period of some three score years and ten. If we go a step farther and consider the length of time over which our information by direct communication from another individual extends, we may admit a space of some one hundred and forty years. Going yet a little farther, but still insisting on direct personal relations, we realize the brevity of historical periods when we hear such words as those recently spoken by Sir William Ramsay, "Why, I myself have seen a man whose father fought in 1745 on the Pretender's side, nearly one hundred and seventy years ago!" Such thoughts as these make us realize how mere oral tradition can readily extend into the far distant past. The farther back we go, however, the more uncertain and the more mingled with falsehood does the mere oral report of past events become. In these days we have a very perfect system of maintaining permanent records of current events, and written records of one kind and another reach back over thousands of years. Some of these, which now yield us most valuable information, may have been originally made without any intention of handing down history. Some, indeed, of the records of the past, are not the work of human hands at all. It is the function of the historical sciences, geology and archæology, to unravel stories of bygone ages, which the earth's crust and the ruins of former architecture hold. Herein lies the characteristic feature of these sciences, that they are concerned with concrete events in absolute time, whereas, such sciences as chemistry and physics are interested in time only as a relative thing: that a certain process takes ten minutes, say, for its completion, may be of interest to the physicist or physical chemist; but whether those ten minutes were reckoned from noon yesterday, or the day before, or any other time, is, for his purpose, absolutely immaterial. Yet indirectly in the abstract physical sciences have contributed their share toward the deciphering of the past. For a knowledge of the natural processes going on before our eyes to-day enables us by inference to reconstruct much of the picture over which the hand of time has drawn its veil. In its direct appeal to our imagination, however, some actual concrete relic of a former epoch speaks with an eloquence that the scientific disposition lacks.

In the course of the process of digging the foundations of a new county hall in London, England, an old Roman boat was discovered about a year ago. The find proved in many respects extremely interesting. It is the first of its kind in England, and the only single decker known. Its date has been fixed by the aid of coins found in the boat, bearing the likeness of Tetricus in Gaul (268-273 A. D.), Carausius, in Britain (263-283) and Electus (293-296). The last mentioned, it will be remembered, set himself up as Emperor of Britain and ruled for seven years until he was defeated and slain by Constantius Chlorus in 296 A. D. The remains of the boat were in a very fragile state. In order to keep them together they were inclosed in wire netting and placed in a deal framework on two lorries which were then dragged by chains up an incline from the lower foundations of the County Hall to the street. Drawn by twelve horses the boat was then conveyed to the new museum at Kensington Palace under police escort. The work took an hour and a half to accomplish. One of our illustrations shows the transportation in progress, a hole having been knocked in a brick wall to admit the passage of the relic. The other illustrations show some details of certain parts of the boat and one of them shows the truck emerging from the County Hall site on its way to Westminster Bridge. In another illustration a man is seen holding up a stump of the old mast. We have in this relic one of the most interesting remains of the Roman occupation of Britain.



The Roman Boat Being Dragged Up an Incline Into the Street.

Reproduced from the *Illustrated London News*.

The Arrival at the Museum.

The Supply of Iron.*

By James F. Kemp.

The plan of preparing an estimate of the world's resources in iron ore has had the cordial support of the Prime Minister of Sweden, and it is a pleasure to acknowledge our indebtedness to him. The plan has been ably carried out by the Swedish committee, and special acknowledgments are due to Dr. J. G. Andersson for the able way in which the difficult task of editing has been performed. As a result we have before us a work which will furnish much food for economic speculation and thought. When we try, however, to project ourselves into the future, we soon find that we are not able to speak with accuracy of mathematics, but we must be content with the attainment of conclusions which, within certain limits, are not unduly remote from the truth. The subject is a complicated one, and may perhaps be best discussed after the mathematical form of assuming, so to speak, an equation which is a function of several variables. By taking one variable at a time and following out the effect of its changes upon the general function, we may, by a series of approximations, in the end establish a solution worthy of confidence.

The future of the iron industry is a function of the following, and perhaps of other variables:

1. The increase in annual production which will make greater demands on the reserves.
2. The decrease of some of the present sources of supply and their final exhaustion.
3. The entrance of new sources of supply now perhaps inaccessible.
4. The gradual decline in average content of iron in the ores used.
5. The increase of expense of production with declining yield.
6. Improvements in existing processes which reduce expenses.
7. The supply of fuel; above all, under present circumstances, of the coking coals.
8. The entrance of new methods of smelting, especially those depending on electricity.
9. The substitution of other materials for iron and steel; among which cement is most important.

We, delegates to the congress, who have come across the ocean, have gazed with profound interest upon the collections in the National Museum which so graphically portray the history of the Scandinavian peoples from the Stone Age, through the Bronze Age, into the Iron Age. It is the Iron Age which many people believe to be the one in which we live. This belief is only partly true. We really live in the Age of Steel, not of Iron, and it is very important that we should

* A contribution to a discussion before the International Geographical Congress, at Stockholm, on August 22nd, 1910.

so regard our own times. Almost all the pig iron produced is used in the manufacture of steel. In the United States, whose output of pig iron the past year was over 25,000,000 tons, and was more than that of the next two nations combined, approximately 90 per cent of the yield of the furnaces is marketed in the form of steel. This ratio will probably continue until we pass from the Age of Steel into that next age of the human race, the Age of Cement, a period which already looms above the horizon and which bids fair in no unimportant way to prolong the life of our iron ore reserves. For many structural purposes reinforced concrete has already replaced steel, and has even been used in the construction of ships.

The report on the iron ore reserves makes it clear that there will be no exhaustion of iron ore of one kind or another for an indefinite period of time. If we consider iron-bearing materials of 30 per cent as ores, there is no lack of a supply for our furnaces. Much apprehension has been felt on this point, and it is reassuring to find our fears in a measure unwarranted.

Iron, as a metal, of course, never can fail, for if we drop 20 or 10 per cent, we find inexhaustible amounts of basic rocks with these percentages, and we are then dealing with raw materials from three to ten times as rich in iron as are the usual copper ores in copper, the next metal to iron in abundance of production.

But the existence of iron ores of even greater yield than 30 to 40 per cent is one thing, and their availability under ordinary conditions of smelting is another. Iron must be produced at low cost if it is to continue to fill its present place in modern civilization, and thus the sources of supply are restricted to comparatively few regions. Almost all the iron and steel of the world is now produced in Western Europe and North America, roughly about 60 per cent in the former and 40 per cent in the latter. In North America the industry is almost all in the eastern part of the country, whether it be in Canada or the United States. If, therefore, we consider the actual facts of production, we necessarily restrict ourselves to a comparatively small part of both Europe and North America. Again, if we consider the population of the world at large, and the population of the countries that produce the iron and steel, the latter is a small fraction.

When, therefore, we speak of the world's reserves of iron ore, if we have in our minds the entire surface of the globe, we are discussing a matter that is largely of academic interest. But if we come down to the business of producing iron and steel as an economic matter, we must eliminate from consideration as affecting the large features of the immediate future all but that small part of the world that lies in Western Europe and Eastern North America.

What, then, is the outlook in these larger producing areas?

Of the United States I can speak with most intimate knowledge, but they are far removed from the countries of Europe, and the iron industry has not yet developed international features except in the importation of ore. The larger features of its future can be summarized in a few words. There are two principal and several minor sources of supply; the Lake Superior region and the Alabama region comprise the former; the Appalachian mountains almost all the latter. The Lake Superior region furnishes four-fifths of the American ores, and one State, Minnesota, supplies more than one-half. The ores are low in phosphorus and sulphur, relatively high in silica, and are very cheaply mined. The ores formerly yielded 60 per cent and over in iron. Now they average somewhat over 50 per cent. At 40 per cent, which is still comparatively high, considering the world at large, the amount is inexhaustible. The ores are transported from several hundreds to over one thousand miles in order to meet the coke and be smelted to the best advantage.

In Alabama, and to a less degree in neighboring States, the ores formerly yielded from 40 to 50 per cent, but the most important variety has now settled down to about 37 per cent, a yield which will not essentially change for many years to come. The ores thus are comparable with the minettes of Germany and France. The coal, the limestone and the ore are all within a few miles of each other, so that the low cost of production is not equaled elsewhere in America. The ores were silicious in early times, when they were obtained near the surface. In depth they have become basic. They are stratified and can be estimated as accurately as coal seams. The ores are moderately high in phosphorus, much above the acid-bessemer limits. Other sources of supply contribute lesser amounts of ore in the Alabama region, and still additional sources are found along the Appalachian mountains, but the chief producers have been reviewed above. The reserves are sufficient for many years to come.

West of the Mississippi the iron industry is relatively small; one moderately large plant is in operation at Pueblo, in Colorado, and another is just being completed on Puget Sound. The development of Alaskan coal will be an important factor in the future.

The most interesting feature of the next few years will depend upon the development of the new supplies of ores from the northern side of Cuba. Great deposits have been proved by the drill. They lie upon the surface and will be cheaply mined by steam shovels. When calcined and freed of their abundant moisture they will supply an ore above 40 per cent in iron, almost entirely free from phosphorus and sulphur, but containing chromium and nickel oxides. The anticipation is entertained that they will greatly revive the steel industry on the Atlantic seaboard, if they do not also lead to the construction of new and extensive plants.

In America, therefore, so far as ore is concerned, there is no prospect of a serious change for an indefinite period. America has been a relatively new country of great distances. Means of transportation calling for steel have been absolutely essential to development. Steel is now employed also in enormous quantity for structural purposes, since all large buildings—the "skyscrapers"—have a framework of steel; but cement is being more and more utilized, and will probably in time affect the consumption of steel in no unimportant way.

Aside from America, in particular, I can only speak of the iron industry in general terms.

In forecasting the future the first disposition is to divide the tons of reserves by the annual production, and thus estimate the life of the mines. I am, however, reminded that in the last fifty years the production has increased by leaps and bounds, as Mr. Van Hise made clear in his address at the opening of the Congress. This rapid increase is true not only of the United States, but especially in later years of Germany. An element of uncertainty is thus introduced into the first simple calculation and the life of the reserves is correspondingly shortened.

On the other hand, in the older iron-producing countries the railways are now built; the great public improvements are largely completed, so that for these purposes the supply of iron or steel is not now required. The iron, moreover, already in the metallic state, steadily accumulates for reworking. We cannot anticipate the continuance of the geometric rate of increase. We are more likely to attain a fairly stable annual output. Just what this production will be, it is difficult to state, but the supply of fuel of which I shall speak in a moment is an important factor.

Undoubtedly some of the present sources of supply will decrease, and finally will be exhausted. Of this feature I am inclined to speak with reserve because most of us have thought that the iron ores of England and the Bilbao ores in Spain were approaching exhaustion, whereas we have learned from the reports to the Congress that new reserves have been opened up by further exploration; the Bilbao ores, for example, can scarcely be regarded as nearing their end, as over sixty millions of tons remain to be utilized. Nevertheless, there are doubtless some present producers which before long will cease to ship. For the furnaces thus deprived of their old sources of supply, new ones must be found. Apparently in these relations Sweden, Algeria, Newfoundland, Cuba and Brazil will come more and more to the front. Assuredly there is a future of increasing importance for the exporting countries. Nevertheless, as local sources of supply decline we must anticipate tariffs and legislation looking toward the conservation of natural resources; these will operate to postpone exhaustion. There are thus antagonistic influences which must be balanced in any forecast worthy of confidence.

In some important producing areas, especially in the United States, a gradual decline in the average percentage of iron in the ore is inevitable. The decline is most marked in those countries where the richest ore has been naturally the first to be utilized. But the percentages, although lower than those hitherto available, will soon be fairly stable in America, and they have already practically reached this condition in Germany. Changes will then only be apparent over long periods of years. With the lowering of percentages, and an amelioration of the conditions of production, a wider range of ores becomes available, so that lowering is checked. There is thus a delicate and interesting balance maintained by these influences.

With the lowering of the percentage of iron in the ore, the cost of production naturally increases. More barren material passes through the furnace, with decreasing product, and increasing expense for fuel. From this cause alone one might infer a decrease in output. But, on the other hand, improvements in processes of smelting have appeared from time to time, and have more than neutralized these effects. In the United States, for example, furnaces have grown enormously in size and capacity. The recent invention of my countryman, James Gayley, has tended to greatly increase the efficiency and the uniformity of operation. Mr. Gayley passes the incoming air of the blast through a series of coils, cooled below the freezing point of water by a very cold solution of some salt such as calcium chloride, so that all the moisture is chilled from the air, which then enters the stoves in a thoroughly dried condition. The accumulated moisture, frozen to the coils, can, when necessary, be melted off by the outgoing heated gases, while the incoming air traverses a second cold chamber. By such an improvement as this or by others likely to be made as time goes by, the effects of decreasing percentages have been offset and again a delicate and interesting balance of opposing forces has been established.

Let us now assume that essentially the methods of smelting which are practised to-day will remain in force for a long period of years. The iron ore goes first to a blast furnace in which, in the vast majority of cases, it is reduced by coke to pig iron. Roughly speaking, one ton of coke is required to produce one ton of pig iron. For the one ton of coke about 1½ tons of raw coal are necessary. If our ores yield 50 per cent in iron, then for each two tons of ore 1½ tons of coal are utilized, and that coal must possess superior qualities in order not to crush down under the heavy burden of a modern blast furnace. In so far as the future of the iron industry is concerned, the serious question is not alone the supply of iron ore, but also the supply of coking coal. It will not suffice in these relations to say that this country or that has so many thousands of square miles or square kilometers of coal fields, because only a relatively small part of the coal fields yields the right sort of coal. We must know how much of the latter the world possesses, and then how much of this supply is near enough to blast furnaces to be utilized without excessive transportation. The coal supply would seem to me to be the next question which a future International Geological Congress might most appropriately take up. Not until these data are at command can the remoter future of the iron industry be suitably forecast.

But, may we ask, are our present methods of the reduction of iron destined to continue? To this it may be replied that with the present outlook electric smelting alone seems likely to introduce changes, and so far as it can be employed only to the following degree: In the reactions of a blast furnace about two-thirds of the fuel is employed in supplying the necessary heat and one-third in the reduction of the iron oxide. Electrical energy, supplied by water power, may replace the two-thirds of the fuel as a source of heat; the remaining one-third will always be necessary. In countries where there is abundant and practicable water power, electric smelting may thus be feasible. Charcoal may even in some furnaces entirely replace coke, over which, being a purer source of carbon, it has manifest advantages. Poor charcoal such as may be obtained from refuse lumber may perhaps suffice, so that to some extent the demands upon the coking coals may be reduced and the life of the reserves may be prolonged. Obviously in countries such as England, with limited water power, but with great supplies of coking coal and great iron interests, electric smelting can be of small importance except in so far as it may enable other lands, such as Scandinavia, to export to it some supplies of iron, necessarily furnished at sufficiently low cost. Electric smelting is in its infancy as yet, but it is of sufficient promise to deserve mention as a possibly important factor in the future.

The final variable in our function which calls for brief mention relates to the substitution of other materials for iron and steel as time goes by. Of these cement seems to be the one of most serious moment, and only in so far as it may supplant structural steel.

In the form of reinforced concrete cement is a material which grows in favor and in use. Some steel is of course used in its manufacture, and the cement is thus only in part a substitute, but its potentialities are sufficient to justify its mention. No one can accurately estimate its future influence.

In conclusion I may repeat that the subject is complex. That the future of the iron industry is a function of a number of fairly independent variables is clear. Some of the variables neutralize each other. Some of the variations we cannot fully trace. On the whole, for many years to come, I believe the iron industry will continue without any very fundamental changes.—*The Chemical Engineer.*

Use for Mica

Coarsely ground or "bran" mica is used to coat the surface of composition-roofing material, to prevent the tar or other composition used in its manufacture from sticking when the material is rolled for shipping.—*Engineering Mining Journal.*

"Historiometry" as an Exact Science

Quantitative Methods in the Study of History

The name "Historiometry" has been proposed* for "that class of researches, in which the facts of history have been subjected to statistical treatment according to some method of measurement more or less objective or impersonal in its nature." "These researches," says F. A. Woods in a recent number of *Science*, "have chiefly had in view the listing and grading of historical characters, either for the purpose of studying mental heredity or for the better appreciation of problems associated with the psychology of genius. Researches of this type are capable of a far greater expansion and application than is generally supposed. They can be applied to events as well as to individuals. They can, by treating the vast store of human records which exist in books as material for the construction of an exact science, work towards the solution of a wide range of historical problems, such as the causes underlying the rise and fall of nations or other fundamental questions in history.

"Before anything can be done which shall give general satisfaction and agreement it will be necessary for this subdivision of science to justify itself, to measure its own shortcomings, to appreciate its own limitations, as well as to prove its own right to recognition of independent estate.

"If we are to fathom historical causation by objective methods it is obligatory first to prove that history itself, as we commonly find it in the printed records, is a sufficiently valid account of what actually happened. Second, it is equally necessary to find proof that the objective methods correctly deal with these facts. It might be supposed that the second proof awaits the first; but this is not necessarily so. If the records themselves were very much at fault, so that the statement of historians were very far from ideal truth, or if the objective methods of collecting and analyzing these statements were subject to a large error (or if both these forces were in play) then it would be difficult to find wherein the trouble lay. But if, on the contrary, it be that history as we find it is in its important statements a fair representation of the truth, and if the methods of historiometry which deal with these records are also sound, then it is not difficult to prove both propositions at the same time.

"I will give some instances to illustrate this, which show that such is the case for several types of historical records and for several methods of history measurements. This could not be done did we not possess some third criterion, some third standard of comparison of a non-historical nature. One such non-historical criterion is furnished by the known correlation ratios for resemblances between close blood relatives as determined in the anthropometric laboratory. These have been worked out and accurately measured for mental and moral traits, stature, head index and length of forearm. I have shown in "Heredity in Royalty" that if the members of royal families are graded by the adjectives applied to them by historians and encyclopædists and then the coefficients of resemblance are measured between the near of kin, who have been so graded, these coefficients (historiometric) substantially agree with the anthropometric. Such would not be the case if historians perverted the truth greatly, or if for any other reason the truth were largely unattainable. To make this clear it is only necessary to think what the result would be if history were merely "a pack of lies agreed upon" as the extreme view puts it. We should then fail to properly pick out our true intellectual giants and runts. The result would be nothing but confusion. A whole series of errors would be distributed at random. This would act like rain on waves and flatten down to a common level the real differences between the individuals. The correlation measurements would fall and we should get no results comparable to those obtained from the delicate and accurate measurements of the anthropometric laboratory.

"Furthermore, any weakness in the method of grading, any failure to properly classify the great men in the high grades and the degenerates in their proper grades would work in precisely the same direction to lower the correlation coefficients. The supposed errors of history and the difficulties of grading act as two united strains of tension to pull the coefficients down toward zero, which would be the coefficient for random distribution. If the coefficient can stand the strain without declining, then, roughly speaking, we may conclude both that the historical foundation is just and that the method of procedure is sound.

"As an illustration of method may be quoted a series of tests which were performed by the trying out a standard biographical dictionary (historical persons) against two lists of contemporaries (non-historical persons) and all three in terms of still another set of facts, namely birthplaces of distinguished Americans.

"As concerns American history, one fact is very evident at the start, whatever be the method of grading as applied to Americans or whatever be the mental eminence graded, some States in the Union, some sections of the country, have produced more eminence than others far beyond the expectation from their respective white populations. In this regard Massachusetts always leads, and Connecticut is always second, and certain Southern States are always behind, and fail to render their expected quota. Furthermore, the higher the grade of the individuals the greater and greater becomes the proportion of those born in Massachusetts. This may be expressed as a ratio, ρ into the random expectation. Thus if there were no forces at work beyond chance distribution the ratios for all sections of the country would be expressed by unity, $\rho = 1$. If there be found twice as many persons born in a certain locality as one would expect from the population let it be expressed as $\rho = 2$, three times as many, $\rho = 3$, etc. These ratios are easily computed and can be expressed as fractions or with decimals. I have computed these ratios for the thirteen original States, but will present here only the statistics from Massachusetts and Virginia.

It will be seen in the table that Massachusetts has never failed to produce twice as many eminent men as the population would lead one to expect, and has for some ranks and types of achievement produced about four times the expectation. ρ ranges between 2.1 and 4.7. Virginia, on the contrary, has but rarely produced as many as might be expected from the large white population and the ratios in the same table are either below the expectation or not significantly above it.

"Regarding the tables for the two contrasted States, Massachusetts and Virginia, and following down through the columns marked 'ratios, or number of times the random expectation according to the population at the approximate age of their birth,' one sees first that the Massachusetts ratios run from 2.1 to 3.9 and the Virginia from 0.2 to 1.1. The higher Massachusetts ratios are associated with the lists of names in which the standards for admission to the lists are higher—that is, specially selected groups of the more eminent.

"There is also to be seen a probably significant gain in the ratios for Massachusetts from the census of 1790 to 1850. A further study of this special phenomenon might develop some interesting conclusions. The ratio also rises when only those in *Lippincott's* are considered who have received adjectives of praise. Nine-tenths of the persons named in this dictionary are given a passing notice by the editors and nothing critical is said of their lives or their work beyond the barest record. About one-tenth receive such adjectives of praise as 'celebrated,' 'illustrious,' 'eminent,' 'famous,' 'noted,' etc.

"*A priori* we may suppose that these represent an extra superior group as compared with the other nine-tenths. *A posteriori* the supposition is verified, because how else can be explained the rise in the ratio for Massachusetts from 2.8 to 3.8? If this 'adjective method' did not select a superior group it would not raise the ratios, or in other words draw it further away from random hazard for which $\rho = 1$. The more accurately it seizes hold of the right persons and justly expresses real differences dependent upon natural causes the more it will raise this ratio. One can now see how it is possible in this way, and in similar ways, to actually test the validity of any method of selection. Its value depends, among other things, upon its ability to raise, or lower, a ratio in a proper degree suitable to the case in hand, so that the ratios shall fit in, and harmonize with other ratios and other results.

"If, for instance, the 'space method,' or the selecting of 234 men who have had the most space allotted to them in the dictionary, had not raised the Massachusetts ratio from 2.8 to any more than say 2.9 or 3.0 we might be justified in concluding that this method was inferior in accuracy to the 'adjective method.' As it turns out, it raises the ratio to 3.6. So one suspects that the 'space method' is not quite as accurate as the 'adjective method,' since it does not raise the ratio as much though it deals with a smaller group. Of course one instance like this does not decide anything. I merely give it as an illustration of the ways in which historiometry may proceed.

"I have also essayed a new method, namely, selecting from *Lippincott's* a list composed of all those Americans whose biographies have been written and published in separate works. This constitutes a very small and presumably correspondingly select group, 129 in number. The ratio for Massachusetts is here seen to rise to 3.9, practically the maximum. It should of course do so if the method is sound and is successful in seizing hold of the right men. This may prove a very accurate, practical and rapid method of objectively listing great men in ancient or modern history, subject of course to such limitations and adjustments as special problems may require.

"The questions here touched upon concern only the individuals, but I know from material as yet unpublished that the quantitative objective method can be applied to events as well as to persons. If its validity for the study of individuals can be securely grounded, then its application to events will naturally follow and will be thereby the more easily and surely established."

List of Names	Total in the List Born in U. S. A.	Number Born in Massachusetts	Number Born in Virginia	Ratios, or Number of Times the Random Expectation According to the Population at the Time of their Birth	
				Mass.	Virginia
Lippincott's "Biographical Dictionary," edition of 1895.	3,227	711	231	$\rho = 2.8$	$\rho = .6$
Same dictionary.					
Americans born A.D. 1785–A.D. 1794	302	75	22	$\rho = 2.1$	$\rho = .6$
Born A.D. 1795–A.D. 1804	370	79	25	$\rho = 2.2$	$\rho = .6$
Born A.D. 1805–A.D. 1814	464	96	23	$\rho = 2.6$	$\rho = .5$
Born A.D. 1815–A.D. 1824	513	97	33	$\rho = 2.9$	$\rho = .8$
Born A.D. 1825–A.D. 1834	363	74	19	$\rho = 3.6$	$\rho = .8$
Born A.D. 1835–A.D. 1854	343	58	15	$\rho = 3.5$	$\rho = .6$
Average of the above six lists	2,355	479	137	$\rho = 2.8$	$\rho = .65$
Same dictionary, Americans who have received any adjectives of praise	320	95	23	$\rho = 3.8$	$\rho = .6$
Same dictionary, Americans who have been allotted extra space (20 lines)	234	67	20	$\rho = 3.6$	$\rho = .8$
Same dictionary, Americans about whom books have been written	129	39	14	$\rho = 3.9$	$\rho = .9$
Same dictionary, practical types only. Bankers, merchants, lawyers, politicians, government officials, engineers, manufacturers, soldiers	1,266	235	143	$\rho = 3.4$	$\rho = 1.03$
Same dictionary, selected list of the greater among the practical types. (Adjective, space and biographical method combined)	232	60	29	$\rho = 3.0$	$\rho = 1.1$
"Who's Who in America," edition 1908-09	14,227	1,650	493	$\rho = 2.6$	$\rho = .9$
"Who's Who in America," practical types only (initials A–C)	1,131	132	33	$\rho = 2.5$	$\rho = .8$
"Who's Who in America," lawyers, judges, congressmen, government officials (initials A–C)	580	60	23	$\rho = 2.2$	$\rho = .9$
"Who's Who in America," engineers, inventors, architects (A–C)	134	16	3	$\rho = 2.5$	$\rho = .5$
"Who's Who in America," army and navy (A–C)	170	18	5	$\rho = 2.5$	$\rho = .7$
"Who's Who in America," business men, financiers, railway officials, manufacturers (A–C)	247	38	2	$\rho = 3.2$	$\rho = .2$
"American Men of Science," 1906, all persons	about 4,000	436	not yet calculated	$\rho = 2.7$	
"American Men of Science," 1906, the leading thousand.	867	134	14	$\rho = 3.4$	$\rho = .4$
"American Men of Science," 1910, the leading thousand.	874	131	17	$\rho = 3.4$	$\rho = .5$
Hall of fame (list slightly extended as in Science, N.S., Vol. XXXII., No. 813, p. 158)	50	20	7	$\rho = 3.3$	$\rho = .9$

A Black Day in Aviation

Four Aviators Killed in France and America

By John Jay Ide

On the second of September two well-known members of the aviation corps of the French army were killed, in sister machines, within half an hour of each other; and the primary cause of the two accidents was the same. Capt. Camine and Lieut. de Grailly left the aviation ground at Buc on R. E. P. monoplanes shortly before five o'clock in the morning for Vesoul, where they were to take part in the maneuvers of the 7th Army Corps.

Camine's machine was slightly slower than that of his companion and the two were soon separated by a considerable distance. When near the village of Vauvilliers, a little more than an hour after leaving Buc, the right wing of Capt. Camine's monoplane broke, and pieces of wood and fabric fell to the ground. The machine pivoted on itself, described two spirals, and pitched down to the ground striking in a ditch bordering the road. The pilot was thrown 30 feet from the wreckage and killed instantly. He had seen his right wing break, stopped his motor and tried his best to reach the ground safely. He successfully cleared some telegraph wires and if the undercarriage of his machine had not fallen into the ditch he might not have been killed, as the wing of the R. E. P. did not break off near the fuselage but quite a distance out.

Unconscious of the fate of his companion Lieut. de Grailly continued his journey. About half-past six near Rigny-la-Nonneuse four peasants saw his red monoplane coming from the direction of Paris. While they were looking up at it the motor stopped and the machine started to glide down as if the pilot wished to land. At the same time part of one of the wings seemed to break away and several pieces of wood fell from the machine, as had happened in Capt. Camine's case. The machine, however, came safely to earth, but the shock of landing caused the gasoline tank to leak and, a short circuit occurring at the same time, the machine burst into flames. Before the unfortunate pilot could free himself from his belt he was burned to death, all the efforts of the peasants to extinguish the fire by throwing earth on the machine being in vain. The tires and one of the elevators were all that remained intact after the flames had died down. The cause of the breakage of the wings of the two machines is most obscure. The weather was ideal for flying, the early hour preventing any possibility of a disturbed atmosphere. It would seem, however, that the coefficient of safety of the wings could not have been sufficient. Another lesson to be learned is that if a belt is used it must be instantly detachable.

Capt. Camine and Lieut. de Grailly were the tenth and eleventh victims among the officer aviators of France; but the enthusiasm of the French army for the "Fourth Arm"—as aviation is called—is such that the breaches caused in its ranks will always be immediately filled up.

Lieutenant de Grailly, Who Was Burned to Death When the Gasoline Ignited After a Hard Landing.

On the same day that the two gallant officers fell to their death, Marron, the chief pilot of the Savary school near Chartres, was killed. Desiring to try for the Michelin cup, he had calculated that in order to improve on the 1,200 kilometers which Helen on the Nieuport had made he would have to fly eighteen hours on account of the slower speed of his biplane. As the attempt was to begin at night Marron had arranged an electric lamp on the machine to illuminate the gages and indicators on the dashboard. Fires were lighted in the aerodrome as guides for the pilot when he should return from each 100-kilometer lap.

John J. Frisbie, An American Aviator, Who Was Killed While Flying for the Crowd at a Kansas Fair When the Weather Was Not Favorable.

The aviator left the aerodrome at 7:02 P. M., but at the end of several minutes, near Bouchéres-les-Pierres, the motor failed and he had to descend "*en vol plané*." Suddenly perceiving an obstacle, Marron turned to the left to avoid it so brusquely that the biplane fell in a mass to the ground.

Some laborers who were leaving the fields ran up and dragged the unfortunate aviator out of the wreck of his machine. Marron had died instantly from a broken neck. A few minutes later someone lighted a match and accidentally set fire to the vapor escaping from the gasoline tank, which the shock of landing had caused to leak. The flames, which were quickly extinguished, burned the clothing of the unfortunate pilot. This caused the rumor that Marron had met a fate similar to that of Lieut. de Grailly.

After the accidents a military commission and the constructor began an investigation to determine their cause. The results of their efforts is embodied in the following letter which M. Esnault-Pelterie sent to the press.

"Dear Sir: Following the two terrible accidents which have cost the lives of Capt. Camine and Lieut. de Grailly, a very thorough investigation took place for the purpose of finding the cause of these two apparently similar catastrophes.

"Wilful damage has wrongly been charged.

"The two inquiries followed by the army and by myself have led to the same conclusion and I wish to inform you of it as I am convinced that its publication by you can be beneficial.

"We are convinced that in the wings, which were not made by me, glue was used against my orders—perhaps by the negligence of a workman—for attaching the fabric to the trailing edge of the wing. It was impossible to detect this on taking delivery of the machines.

"Now we have proved, by the pieces picked up at the scenes of the accidents, that where this glue was used the fabric lost all its strength.

"Notwithstanding this failure of the fabric, thanks to their coolness and skill, the unhappy officers had succeeded in reaching the ground almost as if nothing had happened, contrary to what has been stated.

"Fate unfortunately decreed that poor Capt. Camine should run into a bank, while as to the unhappy De Grailly, his landing had been almost normal, when from some unexplained cause, the gasoline tank exploded, killing him instantly in his machine.

"I believe that it is my duty to let you know the primary cause of these two terrible accidents in the hope that this communication may perhaps prevent their recurrence.

"Yours sincerely,

(Signed) "R. Esnault-Pelterie."

America too suffered on the day in question, for the life of one of her veterans in the aeronautic exhibition business was needlessly sacrificed. John J. Frisbie was making flights, at Norton, Kan., with a Curtiss biplane—the very machine, in fact, with which Glenn H. Curtiss conducted his hydro-aeroplane experiments at San Diego last winter. The machine was tail heavy, and the engine had been moved forward several inches after the flight the day before. Frisbie decided not to attempt a flight on the second day, as the wind was strong and puffy and as he was not sure the aeroplane was properly balanced. But the crowd began to jeer at him, and so, to appease the rabble at the fair grounds, he flew. He went out of the grounds all right, but on his return, in avoiding hitting some of the spectators, the end of one plane struck a building and the machine plunged to the ground. Frisbie died from his injuries a few hours later. The radiator fell upon him, but not the motor. Once more had a life been sacrificed to make sport for the multitude.

In an analogous manner was the life of Edouard Nieuport, one of France's best constructors and aviators, snuffed out on the 15th ult. M. Nieuport flew from Chalons to Verdun in a strong wind for the purpose of taking part in the maneuvers. Soon after he reached Verdun some officers arrived and expressed a wish to see him fly. He immediately ascended and circled the field, making exceedingly sharp turns and astonishing everybody by his skill and daring. While descending and making an especially sharp turn, with the machine banked heavily, it was struck by a violent gust of wind which overturned it or caused it to dive to the ground vertically. Nieuport was so severely injured internally (chiefly about the chest) that he died a few hours later. His loss is keenly felt by the world of aviation, in which he had made a name for himself and done honor to France. Early this year he made new speed records up to 100 kilometers with one, two and three passengers, while on July 1st Weymann won the International Cup Race in England with a 100-horse-power Gnome-engined Nieuport monoplane and Nieuport himself finished third. Besides a peculiar-shaped body, or fuselage, the wings of his machine are almost flat, with a sharp, wedge-shaped front edge. The body is completely covered, only the head of the aviator protruding when extreme speed is aimed at, as was the case when our photograph of Nieuport was taken. M. Nieuport was but 36 years of age. Like the brothers Farman, he had been first a cyclist and next an automobilist. He engaged in the latter industry and the Nieuport magneto and spark plugs are widely used in France. For his monoplane he invented a double-opposed cylinder motor which, although of but 28 horse-power, flew his machine at record speed.

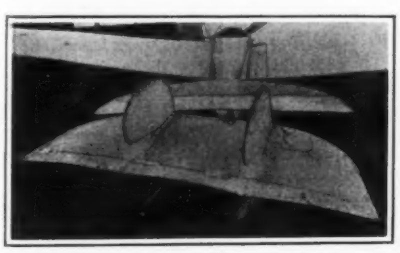
Capt. Camine, Who Was Killed by the Fall When the Wing Broke on His R. E. P. Monoplane.

M. Nieuport got his first start from the invention of a compact storage battery for motor cycles some thir-

teen years ago. This battery was only about one-sixth of the size and weight of the cumbersome batteries in use up to that time, and furthermore, it was about the first dry storage battery that had been introduced. He offered to sell his invention for one hundred francs, but, in thinking it over, he changed his mind and started to manufacture in a small way himself.

Edouard Nieuport, Builder of the Fastest Aeroplane in the World, Who Lost His Life While Flying in a Puffy Wind to Satisfy Some French Officers.

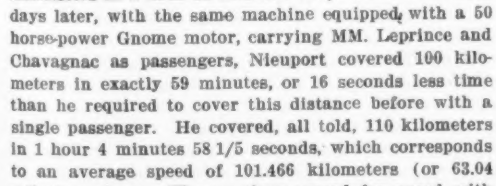
The battery was a decided success, and it was followed by the invention of the Nieuport magneto, spark plug, and finally the aviation motor. The money he made in ignition devices allowed of M. Nieuport's plunging into aviation in the early days. He experimented considerably in a quiet way, but it was only about a year and a half ago that he met with success. The first part of the present year he told an old friend from America who visited him that he believed he had struck the right idea for the fastest aeroplane in the world. It was only a couple of months after this that he began to prove his statement, for on the 6th of March, at Mourmelon, with M. Paul Leprince as a



Combined Horizontal Rudder and Twin Vertical Rudders.

These combined rudders, mounted to swing in two directions, were used early in the present year. They are now obsolete.

passenger, he beat the record of distances covered in one hour by flying 101.250 kilometers (62.91 miles), in exactly sixty minutes. The hundred kilometer mark was covered in 59 minutes 16 seconds, and 150 kilometers in 1 hour 22 minutes 45 2/5 seconds. Three days later, with the same machine equipped with a 50 horse-power Gnome motor, carrying MM. Leprince and Chavagnac as passengers, Nieuport covered 100 kilometers in exactly 59 minutes, or 16 seconds less time than he required to cover this distance before with a single passenger. He covered, all told, 110 kilometers in 1 hour 4 minutes 58 1/5 seconds, which corresponds to an average speed of 101.466 kilometers (or 63.04 miles) an hour. The previous record for speed with



Tail of Nieuport Monoplane Fitted With Twin Vertical Rudders.

As now constructed, a single vertical rudder is placed between the two halves of the horizontal rudder, which is hinged to the rear edge of the tail.

two passengers was 38 minutes 37 2/5 seconds for 50 kilometers, as against 29 minutes 39 2/5 seconds scored by Nieuport, while Breguet's record for 100 kilometers was 1 hour 15 minutes 17 2/5 seconds, as against the 59 minutes and 8 seconds of Nieuport. Nieuport's average for the entire distance was 101.466 kilometers (63.04 miles) an hour, while in one round of the course he made 102.855 kilometers (63.91 miles) an hour.

After this new record at speed when carrying passengers, Nieuport made a new record when flying alone in his own machine, equipped with his own motor, and his own ignition outfit. He covered 80 kilometers in 44 minutes 52 2/5 seconds, which is equivalent to a speed of 109 kilometers (or 67.72 miles) an hour. Leblanc's record in the Bennett Cup race at Belmont Park the previous October, when he was flying a 100 horse-power Gnome-engined Blériot, was 44 minutes, 29½ seconds for 80 kilometers, so that Nieuport, with his own 50 horse-power motor, came within 22 seconds of equalling the Blériot monoplane equipped with twice the power.

When experimenting with the racer which he had built for the Bennett Cup race early in June, M. Nieuport again broke the record for speed with one passenger. Flying over a 5-kilometer course, on June 12th, at Mourmelon, he covered 50 kilometers in 28 minutes 9 4/5 seconds, 100 kilometers in 56 minutes 47 2/5 seconds, and 150 kilometers in 1 hour 28 minutes 24 2/5 seconds. His average speed was, therefore, 105½ kilometers (65.55 miles) per hour, although he made one circit at the urate of 108 kilometers (67.1 miles) an hour. This record was made with his 70 horse-power Gnome motor.

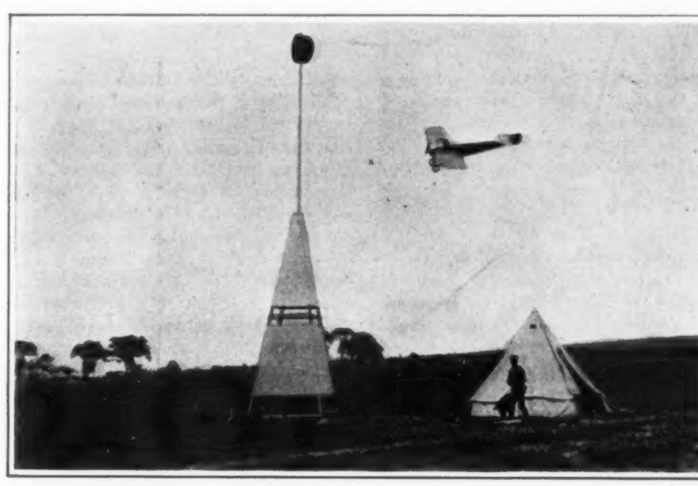
On June 16th, in a speed trial alone, he covered 50 kilometers in 23 minutes 10 seconds, and 100 kilometers in 46 minutes 27 2/5 seconds, while Leblanc's best time for these distances on his new 100-horse-power small-winged Blériot was 24 minutes 30 4/5 seconds and 48 minutes 58 1/5 seconds, respectively. Nieuport was obliged to descend after covering 145 kilometers at an average speed of 129.217 kilometers (80.29 miles) per hour. His fastest circuit was made at the rate of 130.057 kilometers (80.81 miles) per hour.

In the Bennett race itself, Weymann used a 100-horse-power Nieuport monoplane, while Nieuport flew a 70-horse-power machine, and Chevalier a stock machine with a 28-horse-power double-opposed cylinder Nieuport motor. Nieuport succeeded in finishing third, his time for the 150 kilometers being 1 hour 14 minutes 37 3/5 seconds (74.94 miles per hour), while Chevalier covered 10 laps in 37 minutes 37 1/5 seconds (59.3 miles per hour).

Before he died Nieuport saw his monoplane the holder of new records for the longest flight in a day around a 100-kilometer closed circuit across country, for twice Emmanuel Helen broke the record for the French Michelin Trophy. On August 26th, using a passenger-carrying Nieuport, and flying over a 102-kilometer course, Helen covered 1,126.4 kilometers (699.91 miles) in 13 hours, 47 minutes, and 19 seconds, while on September 8th, using a faster one-man machine, Helen increased this record to 1,252.8 kilometers (778.45 miles) in 13 hours and 17 minutes actual flying time, which corresponds to an average speed of 58.6 miles an hour. In this instance he made twelve circuits of a 104.4-kilometer course. His time, including stops, was 14 hours 7 minutes 50 seconds. The best previous records were 808 kilometers (502 miles) made on August 9th by Vedrines on a Morane monoplane, and 812 kilometers (504½ miles) covered by Pascal on a Deperdussin monoplane on August 28th. Duval, on a Caudron biplane, covered 800 kilometers (477 miles) on August 31st, and on September 1st and 5th Vedrines flew respectively 468 and 100 kilometers, while Tabuteau, also on a Morane monoplane, covered 410 kilometers.

We have recently witnessed many fine flights in this country by Grahame-White, with a Gnome-engined Nieuport monoplane. Mr. Anderson, a young mechanical engineer of New York city, has acquired one of these machines, and is learning to fly it at Nassau Boulevard. The machine owes its speed to the peculiar shape of the wings and body, in designing which M. Nieuport reduced the head resistance as much as possible by giving the proper stream-line form and imitating somewhat the breast of a bird.

The death of this talented young Frenchman at the age of but 36, has been a great blow to aviation—greater, perhaps, than would have been the loss of any other designer or constructor of aeroplanes in France to-day. The lesson to be drawn therefrom is that designers of aeroplanes who have proved their worth should not take chances in flying their own machines, especially under unfavorable weather conditions.



Weymann Winning the International Cup Race in England on a 100 Horse-Power Nieuport Monoplane.

The race was flown on July 1st, the distance being 93 miles. The time of the winner was 1 hour, 11 minutes, 36 1/5 seconds, which corresponds to an average speed of 78.1 miles an hour.

Electrolytic Copper Free from Arsenic.

An interesting research on the electrolytic deposition of copper from impure sulphates containing arsenic and antimony is published in a doctor dissertation, recently presented by a Chinese student, Ching Yu Weng, to the Columbia University of New York. Arsenic and antimony are common impurities in sulphate lyes; both these metals are precipitated with the copper, which they render brittle, and they favor tree-formation. In his investigation Weng makes use of ordinary impure sulphate, sometimes containing considerable amounts of the two metals, and of this solution and various "addition agents," substances added in order to prevent the deposition of the arsenic and antimony. Taking, in the first instance, the ordinary electrolyte, Weng noticed that the copper began to become distinctly contaminated with arsenic and antimony when the arsenic content of the bath reached 1.5 per cent. When, however, the As content was 6 per cent, the arsenic itself acted as preventive addition, provided that the bath was heated to 50 or 60 deg. C.; when the bath temperature was 40 deg. C. or less, it required the presence of at least 8 per cent of arsenic in the bath to secure the preventive effect. The peculiar phenomenon may be due to a hydrolysis of the arsenic sulphate in the bath, subject to certain temperature and concentration conditions; the hydrolysis would yield arsenious acid (which would not travel to the cathode, and would thus not be deposited) and sulphuric acid. As regards inorganic addition agents, common salt (NaCl) acted best, hydrochloric acid was also fair, sodium sulphate less so, aluminium sulphate improved the deposit slightly, aluminium chloride proved less advantageous. In this effect, again, temperature and arsenic concentration had their influences. Of organic compounds, gelatine and tannin had a decidedly beneficial effect, as they have in many electrolytic baths, though the gelatine at the beginning of the electrolysis seemed to favor the formation of small fern-like growths. Peptones were distinctly injurious. By far the best results were obtained with the addition of both common salt and gelatine, about 0.01 or 0.02 per cent of each of them. Some of the observations which we have noticed are not novel, of course, but the recognition of the peculiar behavior of arsenic, to act as its own preventive at certain concentrations and temperatures, is probably new, though a good deal of what the chemists discover in refineries is not published. The research does not explain all the observations—*Engineering.*

The Laboratory and Commercial Production of Oxygen

A Review of the Principal Methods Proposed

By A. S. Neumark

The date of the discovery of oxygen gas has been given as August 1st, 1774, when J. Priestley prepared this gas for the first time by heating mercuric oxide, but at almost the same time Scheele in Sweden was also producing oxygen in his laboratory. The French chemist Lavoisier gave it its present name (from the Greek oxys, acid, and genao, to produce) for the reason that he supposed it to be the essential constituent of all acids. It was he who perceived its real nature, putting forward the true theory of combustion.

Oxygen is the most abundant of all elements, it makes up by weight fully one-half of the globe, including earth, air and water. However, it exists nowhere in the pure and uncombined state; therefore certain processes are required to isolate it. It can be abstracted by a great many methods which depend on different physical as well as chemical principles. These methods may be classed as follows:

1. By the decomposition by heat of compounds containing oxygen.
2. By the decomposition by chemical means of compounds containing oxygen.
3. By the decomposition by electrical means of water.
4. By the extraction of oxygen from the atmosphere.

Of compounds from which oxygen may be abstracted by dissociation through heat may be mentioned the alkali chlorates, perchlorates, hypochlorites, chromates, manganates, nitrates; also certain oxides (manganese, lead, mercury, etc.). The method mostly used in this country by the small manufacturer and welders, is to heat potassium or sodium chlorate. If potassium chlorate is heated to a temperature of 350 deg. C., it gives off all its oxygen, leaving potassium chloride as a residue, according to the following equation:

$$2KClO_3 = 2KCl + 3O_2.$$

The gas is evolved slowly at first, but soon generation increases rapidly, ending with explosive violence. This can be prevented by adding a catalytic agent, such a manganese dioxide, iron oxide, copper oxide, lead peroxide; also sand and graphite has been recommended. Manganese dioxide (MnO_2) is usually employed for this purpose; however it must be pure and must not contain any coal dust with which the commercial black oxide of manganese sometimes is adulterated. The proper proportion is 1:8 or 1:12. Too much manganese causes the formation of chlorine; if not enough is added, the chlorate will melt before giving off oxygen and generation will then be sudden. A better substitute would be freshly precipitated and ignited iron oxide (Fe_2O_3). Both substances cause the chlorate to give off the oxygen more slowly and continuously than the chlorate alone, and at a considerably lower temperature (at 200 to 210 deg. C. when manganese is used, and at 110 to 120 deg. C. where iron oxide is employed). If sodium chlorate is used instead of the potassium salt, additional precautions are necessary to prevent too rapid generation, as the decomposition of the sodium salt is more exothermic than that of potassium chlorate. The molecular weight of the last being less than that of the potash salt, a greater amount of oxygen per unit of weight can be obtained (16 to 18 per cent). Retorts of a special design should be used; those manufactured by the Oxy-Carbi-Co., New Haven, are probably best adapted for this purpose. Potassium chlorate yields 4¼-4 1/3 cubic feet per pound, at a cost of 2½ cents; sodium-chlorate produces nearly 5 cubic feet, which brings the cost down to 2 cents (and less) per cubic foot. The oxygen after leaving the retort is washed thoroughly in water and caustic soda (or similar chemicals) to remove the chlorine which is always present. The scrubbers usually consist of three barrels partly filled with the washing fluid, the inlet pipes being provided with some device for breaking up the bubbles. The last barrel is connected with a gasholder (gasometer), from which the gas is forced into storage tanks by means of compressors. The latter usually have two stages of compression with intercooling to prevent heating of the cylinders. As an additional precaution the latter can be submerged in water. Oil or other carbonaceous lubricant should never be used, as it is liable to cause ignition and explosion; for the same reason wool or similar material should not be employed as packing; asbestos may be used instead. The oxygen is compressed into either low pressure tanks (225-300 pounds), made of steel and tested to twice the charging pressure or into high pressure tanks (1,200-1,800 pounds per square inch) made of drawn steel with a perfectly smooth inner surface. Small particles of loose iron can cause oxydation and ignition. They should be kept in a cool place, as the rays of the sun can increase the pressure considerably. It is of course much cheaper to generate oxygen in the retorts under sufficient pressure to force it into storage tanks. This would do away with gasometer and compressor and thus occupy very little space. However, the results from this type of generator can not very well be satisfactory. The purity of the gas plays an important part when used for welding; chlorine, for instance, affects the strength of the weld to a great extent. It stands to reason that if three washbarrels are required in the compressor type of oxygen generator, it would require much more washing fluid to remove the impurities in the pressure generator. A single scrubber filled with caustic soda or dry chemicals will never remove the chlorine completely. Then there has to be considered the waste of gas while recharging, which brings down the yield of gas to four cubic feet per pound of chemical. Besides, there is always danger of an accident caused by leaving the valve between the retort and storage tank (or scrubber) closed. After all, the compressor type can be installed for but little more than is asked for pressure generators by some manufacturers, and they produce a gas of the greatest purity and at the lowest possible cost from the chemicals. Both methods mentioned yield the oxygen by external heating of the retorts. Another type is the internally heated type. Here the chlorate (or perchlorate), which must be in large excess and in the powdered state, is mixed with some combustible matter (charcoal, hydrocarbons, cellulose, powdered metals, etc.), and an inert matter (sand, clay, infusorial earth). The "Oxygenit," sold in this country, belongs to this class; it contains chlorate and manganese dioxide in the preparation of 100:13, to which has been added some lamp-black to support combustion. The admixture of manganese dioxide reduces the temperature and prevents the chlorate from melting. This chlorate mixture is placed in asbestos-lined retorts and fired by a match or some kind of ignition powder. Other combinations sometimes used are 100 parts of chlorate and 40 to 60 parts of manganese oxide (with, or without, the addition of infusorial earth); or 100 parts of chlorate, 20 to 40 parts of infusorial earth, and 3 to 5 parts of powdered charcoal. Quite a number of such combinations have been patented by the French chemist Jaubert, who for the past ten years has made a specialty of preparing mixtures giving off oxygen either by ignition or when being brought in contact with water. He is still working along these lines. The retorts used for the compressor type of oxygen generator are usually cylindrical in shape, and made of light steel or wrought iron. Sometimes a series of such retorts is used; or one can be in operation, while another is allowed to coal, and a third is being recharged. Or a large retort, rotating about an axis over a gas flame, is so connected with the gas holder, that the movement of the latter (due to consumption of gas) may cause such movement of the retort as to bring another portion of it over the flame. This action continues automatically until the charge in the retort is exhausted. According to a French patent, a number of retorts communicating with and grouped around a common delivery pipe (which also acts as a support ing axis) are brought in turn over the burner. As soon as one retort is exhausted, the gas shuts off automatically, and brings a fresh retort over the burner, which is relighted. The movement of the retorts and value on the gaspipe is actuated by the movement of a diaphragm, a ratchet wheel and a series of levers. The chlorate is sold in kegs, holding 112 to 120 pounds, at 9 to 10 cents per pound, and is manufactured by an electrolytic process. It usually comes in crystals; the powdered chemical is more expensive, although it gives much better results. Large crystals must never be used, as they will delay the generation of oxygen until the chlorate is melted and then will evolve the gas so suddenly that the latter cannot escape fast enough. The attempt of one of the chlorate manufacturers to mix the chlorate with a small percentage of barium sulphate caused a "blow-out" a couple of years ago at an oxygen plant in New York, doing considerable damage. The manufacturers apparently did not know, that, although an inert powder, barium sulphate increases the decomposition of the chlorate, owing, according to Sodeau, to the formation of barium chlorate by double decomposition. Barium sulphate is one of the heaviest chemicals known, the reason for adding it is, therefore, obvious. However, the entire lot of chlorate (ten kegs) were exchanged for unadulterated sodium chlorate without offering any explanation.

There are a number of proprietary chemicals on the market which evolve oxygen when brought in contact with water, such as epurite, oxone, lavoisite, etc. The two first named preparations are simply fused. sodium peroxide; the cost of oxygen is high (13 to 20 cents per cubic foot) where such chemicals are used, although the gas is of great purity. Sometimes the alkali peroxide is mixed with a small percentage of copper sulphate, potassium permanganate, hypochlorite, etc., and agglomerated by compression. A mixture of 200 parts of bleaching powder and 70 parts of sodium peroxide is often used.

Manganese dioxide alone, when heated to a bright red heat in retorts placed in a furnace, gives off one-third of its oxygen. It requires two and one-third pounds of chemical to obtain one cubic foot of gas. This method is inconvenient on account of the high temperature required.

More practical methods are those where bleaching powder (or any other hypochlorite) is used. If a concentrated and filtered solution of bleaching powder (calcium hypochlorite, chlorinated lime), to which a small quantity of cobalt oxide has been added, is gently heated to 70 or 80 deg. C. a steady stream of oxygen is evolved. If the filtering of the bleaching powder solution should be found inconvenient, a thick paste of the chemical with water may be used (always with the addition of cobalt, nickel or copper oxide). To prevent frothing of this mixture, some paraffin or a few drops of paraffin oil must be added. The oxygen gas is liberated with great ease and regularity, so that this method is well adapted for the small manufacturer. Ten pounds of chlorinated lime (33 per cent) yield about eight cubic feet of gas. Fleitman modifies this process by passing a stream of chlorine through milk of lime, to which has been added some cobalt salt. The following method has first been recommended by Jaubert and is often used. A tank is filled with a solution of bleaching powder (1:6) and a solution of 12 parts of iron sulphate and 3 parts of copper sulphate in 50 parts of water is slowly added. Oxygen is liberated. It is perhaps better to add the iron sulphate to the chlorinated lime, and introduce the copper salt when required. Several patents have been taken out on generators based on this process. They all are provided with agitators to occasionally stir up the residue. If bleaching powder is mixed with slaked lime and heated to redness, oxygen is also given off.

If sulphuric acid is allowed to drop on red hot surfaces, it is decomposed; oxygen and sulphurous acid are disengaged and can easily be separated. Eleven pounds of acid yield 20 cubic feet of oxygen. Zinc sulphate also evolves oxygen when heated. The following method has been tried for the manufacture of commercial oxygen, but has been found impractical on account of the very high heat required. A mixture of plaster of Paris and river sand is heated in retorts, placed in a furnace, to a dull red heat; then superheated steam is injected; oxygen and sulphurous acid are liberated. One pound of plaster of Paris is said to yield 1¼ cubic feet of oxygen.

Oxygen can further be obtained by the action of chlorine on steam at a bright red heat. A generator based on this process has been patented in this country. The chlorine is obtained by subjecting muriatic acid gas and compressed air to heat in the presence of a porous material saturated with a solution of copper chloride. Superheated steam is then brought together with the chlorine, forming muriatic acid gas and oxygen. The former can be used over again. This method can hardly find much practical use, as it is too cumbersome and costly. Alkali nitrates (niter) do not yield pure oxygen, otherwise they could be used for commercial purpose. There are a number of other compounds that evolve oxygen by decomposition by heat or chemical means, but none of them are of any practical value and they are only used for laboratory purpose.

A Viennese engineer proposes to decompose steam into its elements, oxygen and hydrogen. This he accomplishes in a furnace made of chromic iron (being impermeable at all temperatures) at a temperature of 2,912 deg. F. The steam is dissociated by an elec-

tric spark, or a layer of fire brick material, or by means of thin platinum sheets. The decomposition of water into oxygen and hydrogen, by electrolysis, can successfully be used only where power can be had cheap enough or where there is a market for the double volume of hydrogen simultaneously set free with the oxygen. The electrolyte is usually a 20 per cent solution of alkalihydrate, the gases being separated by a diaphragm, placed between the cathode and anode. The electrolytic process is used in Europe to a considerable extent; in this country there are but three such plants to the writer's knowledge. The high cost of electric power, the need for skilled labor and the large floor space required, have made this process too expensive.

Oxygen can also be extracted from the atmosphere. The methods which utilize the atmospheric oxygen may be classed into two groups: the extraction by chemical means and by purely mechanical (physical) means. Of the first named group the following methods may be mentioned:

1. By alternate formation and decomposition of barium dioxide. If barium oxide (BaO) is subjected to a temperature of 500 to 600 deg. C. in a current of air, it takes up oxygen from the latter, forming barium dioxide (BaO_2). By raising the temperature to 800 deg. C. this dioxide is again decomposed, giving off oxygen and passing back into the oxide, the decomposition being expressed as follows: $2BaO_2 = 2BaO + O_2$. This process has first been used by Boussingault, who proposed to use this method for the manufacture of commercial oxygen. However, it was soon found that the barium oxide after several operations lost its power to take up oxygen from the air. It was many years later that the brothers, L. Q. and A. Brin, succeeded in overcoming these difficulties by using reduced pressure during deoxidation, avoiding too high temperature, and, above all, by careful purification of the air. The latter must be completely freed from carbonic acid gas, moisture and organic matter, or else barium hydroxide and carbonate are formed which will make useless the whole expensive charge. Fig. 3 shows the diagram of a plant of this kind (Elkan's oxygen plant in Berlin), consisting of a series of air purifiers, an air pump and a number of retorts placed in a furnace. The pump draws the air through the purifiers into the retorts. As soon as the barium oxide is transformed into the dioxide, the air supply is shut off which causes a rise in temperature; oxygen is liberated and is drawn off and forced into the gasholder. By an arrangement of values—of the "three-way" kind, the same air pump is used, acting alternately as pressure and vacuum pump. Until a few years ago, this has been the most successful process for the production of oxygen gas on a large scale. In this country only two plants have been in operation; a patent is an improved generating plant of this type having been taken out only recently. At the works of the Brin Oxygen Co., London, 140 operations have been made in one day, one pound of baryta yielding one cubic foot of gas (15 per cent pure) at a cost of \$1.80 per 1,000 cubic feet. Such a plant requires a very carefully constructed apparatus, and constant and careful attention.

2. By alternate formation and decomposition of alkaline manganates. Manganese oxide (or peroxide) is heated in a current of air to 450 deg. C., together with some caustic soda, whereupon it takes up oxygen until all the oxide is converted into sodium manganate. Steam is admitted, which decomposes the manganate, disengaging oxygen, and leaving manganese oxide and caustic soda, which is used again for a fresh supply of gas. The originators of this process are Tessie du Motoy and Maréchal. Plants utilizing this system were erected in Paris, Lille, Brussels, Vienna, Frankfort and New York. At the works of the Oxy-Hydrogen Gas Co. in New York (1870) the daily output was from 25,000 to 30,000 cubic feet; a large amount of the oxygen being used for lighting purpose in connection with hydrogen gas, which was obtained by heating calcium-hydrate with anthracite; 2,000 cubic feet of oxygen were used alone for illuminating the work during the building of the Brooklyn Bridge. Oxygen was sold for five cents per cubic foot; the retorts used were nearly six feet long and two feet in diameter. Two chaldrons of cake were used daily, the whole plant requiring the services of three men. This company failed in 1871, the same fate being shared by other firms using this process. It was found that after a time the manganate deteriorates and the yield of oxygen almost ceases. The difficulties were later partly overcome by Fanta, Bowman, Chapman and others, but this process has never met with any practical success. A modification of this process is the one proposed by Stuart, and is still in use. The manganate is in a fused condition, the temperature being constantly kept at 375 to 400 deg. C. At one of the plants using Stuart's process, retorts eight feet deep and two feet wide were used, each retort holding 1,500 pounds. Steam is blown through the bottom and just before the flow of oxygen stops, air is admitted. The cycle of operations lasts 10 to 15 minutes, and a set of four retorts (as described above) is said to furnish 140 to 150,000 cubic feet of gas in 24 hours.

3. By alternate oxidation and deoxidation of cuprous chloride. Dry copper chloride when heated is decomposed into cuprous chloride and chlorine. The former is treated with steam and air at a temperature of 100 to 200 deg. C., whereupon it takes up oxygen, forming copper oxychloride. When this is heated to 400 deg. C. oxygen is liberated, leasing cuprous chloride which is again treated as described above.

4. By decomposition of calcium plumbate (Kassner's method). This substance is obtained by heating an intimate mixture of calcium carbonate (or limestone) with oxide of lead in a current of air. It is decomposed by carbonic acid gas, passing back into calcium carbonate and lead oxide, and liberating oxygen. The plumbate can also be decomposed by a solution of alkali carbonate. Another modification is the following: Hot air and steam are forced alternately through six chambers from opposite directions. The first three chambers are filled with limestone and lead oxide, the following two chambers contain copper oxide, while the last chamber is filled with oxide of iron. A constant stream of oxygen is evolved by oxidation and deoxidation (Claus and Elsner Patent). A similar method is used by the Oxygen Producing Syndicate, London. All these processes have found little favor on account of the complexity and the large amount of labor required.

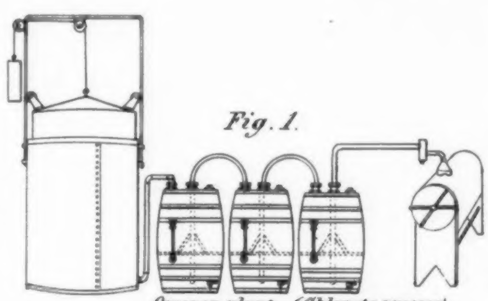


Fig. 1.
Oxygen plant. (Chlorate process)

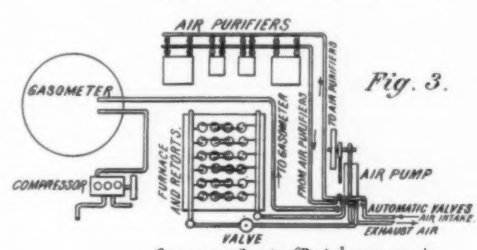


Fig. 3.
Oxygen plant. (Brin's process)

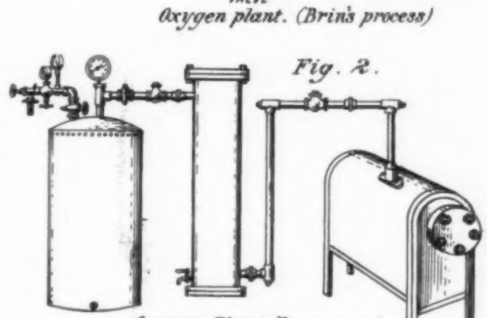


Fig. 2.
Oxygen Plant. (Pressure type)

Methods of extracting oxygen from the atmosphere by mechanical means:

1. Oxygen and nitrogen may be mechanically separated by atmolysis, i. e., by taking advantage of the different rates of diffusion of the two gases (*dialysis*). If air is forced through plates of plaster of Paris, it will be found that the air emerging from the other side of the plates consists of nearly pure nitrogen, most of the oxygen being retained. The property of caoutchouc in thin layers of allowing oxygen to pass through it more readily than nitrogen, has been used and several patents have been taken out for processes of this kind. Margis used bags made of silk and coated with specially treated caoutchouc. A vacuum pump causes the air to pass through the bag, and this air is drawn off by a steam injector. Steam and air pass through a water cooler, where the steam is condensed and the air is drawn off and forced through a second bag and the operation is repeated. One operation yields a 40 per cent oxygen mixture, the following operations bring the concentration up to 60 per cent, 80 per cent and 95 per cent. Neam forces air through only one separator, made of porous clay, having partitions of carbon diaphragms and filled with masses of porous caoutchouc. A rather odd contrivance is the one patented by De Villepigne. However, none of these devices have been of practical value, as the process of dialysis is an extremely slow one.

2. A somewhat more promising method is the one which makes use of the different degrees of solubility of oxygen and nitrogen in water and other liquids. The first patent based on such a process was taken out by Mallet in 1869. In 1871 such a plant was put in practical use in Cologne by Phillipps, who used the oxygen for lighting part of the city with specially constructed oil lamps. Four absorptions of air in water, with recovery of the absorbed air mixture, were used. This yielded a mixture of 75 per cent oxygen and 25 per cent nitrogen; the cost being 39 cents per 276 cubic feet; this being the amount obtained in one hour. A great many patents have since been taken out, some of them only recently; and although most of the claims are for "air rich on oxygen," a gas of 93 to 97 per cent purity can be obtained by a sufficient number of absorptions and expelling of the absorbed gas mixture.

3. By using the absorbing power of porous material for gases. Charcoal is best suitable for this purpose; 25 gallons of quenched charcoal yielding 70 cubic feet of oxygen gas (95 to 96 per cent pure) after one absorption and releasing the absorbed gas when the charcoal is sprinkled with water. The bark of trees and shrubbery also absorb oxygen to a considerable extent; 15 pounds of the bark are said to yield 20 cubic feet of oxygen in 1 hour, the gas being of 98 per cent purity. However, the absorbing power of the bark is not of long duration.

4. By partial evaporation and fractional distillation of liquid air. Of the world's supply of oxygen gas nearly 85 per cent is now produced by this process. It is not the intention of the writer to go into the details of the liquefaction of air and the recovery of the oxygen, inasmuch as this method can hardly be of interest to the small manufacturer. I only wish to outline briefly what has been accomplished in a practical way along these lines in the United States. Whether Prof. Linde of Munich, or Hampson of London, or Charles E. Tripler, of New York, was the first one to build an air liquefier, has not been decided. Tripler began his experiments in 1890, and finished his first liquefier in 1894. The Tripler Liquid Air Company had its plant at 330 7th Avenue, New York city. In the fall of 1900, this firm failed, Tripler having lost in the law suits instituted against him by the Linde interests. In the spring of 1900, Raoul Pictet, of Geneva, came to New York. He began a series of very expensive experiments, endeavoring to use liquid air as a means of producing large quantities of oxygen gas. This was at a time when Tripler had failed to convince the world of science that he could produce liquid air without cost, doing away with fuel of any kind. His perpetual motion scheme was laughed at and he had to hear much bitter criticisms. Therefore, Pictet's claims were not taken seriously and it was pointed out to him that there was no market for oxygen even if his experiments should prove a success. However, he failed to make good. He worked first in Tripler's laboratory and later continued his experiments at the plant of the General Liquid Air and Refrigerating Company, where he was assisted in the work by M. Burger. In spite of their widely circulated claim that with a 500-horse-power plant they were able to produce within 24 hours 3,550,000 cubic feet of oxygen, and 3,550,000 cubic feet of nitrogen, with 3,000 pounds of carbonic acid thrown in for good measure, and this at a cost of only \$75, nothing was done toward the actual manufacture of oxygen on a commercial basis. Pictet left, having accomplished nothing on this side of the Atlantic. It was more than a year later that the first liquid air oxygen was being sold by the Columbia Liquid Air Company, Washington, D. C. According to Mr. E. C. Foster, manager of the works, liquid air was being produced at the rate of 12 to 18 gallons per hour with an expenditure of 150 horse-power. The liquid air contained at an average 35 per cent oxygen. By evaporating two-fifths from the daily output 50 gallons of 70 per cent liquid oxygen could be made, or 5,000 cubic feet of the gas, at a cost of three-tenths cent per cubic foot. The Washington plant was later abandoned, and a new one erected in New York. By the "Eagle Oxygen Company" liquid air oxygen was sold for medical purposes, some also for limelights. The medical oxygen was in most cases of 75 per cent purity, although in some cases a 90 per cent product was put up. The gas tanks were charged without the aid of compressors, by filling a high pressure steel cylinder, surrounded by a vacuum jacket, with the liquid oxygen. The latter was allowed to gradually assume the gaseous state, forcing its way through the filling device, and from here was drawn off into the tanks at the required pressure (225 to 1,250 pounds). Whatever profit was made by the company was used up by constant experimenting of Mr. Foster and his mechanic, John J. Worland. After a short career of 1½ years the Eagle Oxygen Company closed its doors. Remnants of the first liquid

air oxygen apparatus are still buried in the cellar of a shop in Bleeker Street, New York. The British Oxygen Company, London, has secured the Linde patents for Great Britain; they also own the Claude's patents and with their five plants in operation practically control the oxygen market in England. The Linde Air Products Company in this country, controlled by German, English and American capitalists, has four plants in operation, and also owns the Claude's patents if the writer is correctly informed. A company for developing Hildebrand's patents is also being formed and a plant about to be erected. In far-off Los Angeles, the United States Liquid Air and Oxygen Company, using Babrick's patents, has been producing oxygen for the past ten years; while the General Liquid Air Company, of Dover, Del., is making frantic efforts to complete their plant. The oxygen industry in this country is, however, still in its infancy, although the progress that has been made within the past two years is remarkable. In Europe commercial oxygen has been on the market since 1880; Germany being especially active, with France a good second. In 1899 the yearly output of oxygen in Germany was doubled, and the following year trebled. The output in 1902 was 35,000 cubic meters, in 1903 it jumped to 50,000 cubic meters, in 1905 to 90,000 cubic meters, in 1908 to 400,000 cubic meters; the production of France for the same year was 300,000 cubic meters, and for England 100,000 cubic meters. In 1910 more than two million cubic meters of oxygen were sold by manufacturers in Germany, to which must be added the oxygen produced by individual plants, amounting to almost another million cubic meters of oxygen. Of this amount 8,000 cubic meters had been produced by the Brin's process; 342,000 by the electrolytical process, and 2,200,000 cubic meters by fractional distillation of liquid air. The output of oxygen in the United States is far behind those figures. During the latter part of 1910 the monthly output was 30,000 cubic meters (1,060,000 cubic feet) per month; but at present more than two million cubic feet per month are being produced.

Rules Governing the Competition for the $15,000 Flying Machine Prize Offered By Mr. Edwin Gould

1. A prize of $15,000 has been offered by Mr. Edwin Gould for the most perfect and practicable heavier-than-air flying machine, designed and demonstrated in this country, and equipped with two or more complete power plants (separate motors and propellers), so connected that any power plant may be operated independently, or that they may be used together.

CONDITIONS OF ENTRY.

2. Competitors for the prize must file with the Contest Committee complete drawings and specifications of their machines, in which the arrangement of the engines and propellers is clearly shown, with the mechanism for throwing into or out of gear one or all of the engines and propellers. Such entry should be addressed to the Contest Committee of the Gould-Scientific American Prize, 361 Broadway, New York city. Each contestant, in formally entering his machine, must specify its type (monoplane, biplane, helicopter, etc.), give its principal dimensions, the number and sizes of its motors and propellers, its horse-power, fuel-carrying capacity, and the nature of its steering and controlling devices.

3. Entries must be received at the office of the Scientific American on or before June 1st, 1912. Contests will take place July 4th, 1912, and following days. At least two machines must be entered in the contest or the prize will not be awarded.

CONTEST COMMITTEE.

4. The committee will consist of a representative of the Scientific American, a representative of the Aero Club of America, and the representative of some technical institute. This committee shall pass upon the practicability and efficiency of all the machines entered in competition, and they shall also act as judges in determining which machine has made the best flights and complied with the tests upon which the winning of the prize is conditional. The decision of this committee shall be final.

CONDITIONS OF THE TEST.

5. Before making a flight each contestant or his agent must prove to the satisfaction of the Contest Committee that he is able to drive each engine and propeller independently of the other or others, and that he is able to couple up all engines and propellers and drive them in unison. No machine will be allowed to compete unless it can fulfill these requirements to the satisfaction of the Contest Committee. The prize shall not be awarded unless the competitor can demonstrate that he is able to drive his machine in a continuous flight, over a designated course; and for a period of at least one hour he must run with one of his power plants disconnected; also he must drive his engines during said flight alternately and together. Recording tachometers attached to the motors can probably be used to prove such performance.

In the judging of the performances of the various machines, the questions of stability, ease of control and safety will also be taken into consideration by the judges. The machine best fulfilling these conditions shall be awarded the prize.

6. All heavier-than-air machines of any type whatever—aeroplanes, helicopters, ornithopters, etc.—shall be entitled to compete for the prize, but all machines carrying a balloon or gas-containing envelope for purposes of support are excluded from the competition.

7. The flights will be made under reasonable conditions of weather. The judges will, at their discretion, order the flights to begin at any time they may see fit, provided they consider the weather conditions sufficiently favorable.

8. No entry fee will be charged, but the contestant must pay for the transportation of his machine to and from the field of trial.

9. The place of holding the trial shall be determined by the Contest Committee, and the location of such place of trial shall be announced on or about June 1st, 1912.

10. Mr. Edwin Gould, Munn & Co., Inc., publishers of the Scientific American, and the judges who will be selected to pass upon machines, are not to be held responsible for any accident which may occur in storing or demonstrating the machines on the testing ground.

Engineering Notes

Lead-Coating Iron Fittings.—Valves and small fittings made of iron well galvanized on the exterior may be homogeneously covered with lead in the workshop by any mechanic. The method consists in immersing the piece to be coated in water to which a few drops of sulphuric acid have been added. Then, while in the acid water, the piece is readily amalgamated in the usual way by squeezing mercury through close-woven cloth all over its surface and thoroughly rubbing it in. The excess mercury is rubbed off and the piece carefully dried without heat, and then immersed in a bath of lead, which should be well above its melting point, so that it would not tend to solidify by introduction of the cold piece. The casting may be withdrawn after about 20 seconds, and will be found to be homogeneously covered with lead. This method requires the piece to be galvanized before applying the lead.—*The Engineer.*

Corrosion of Rails in Tunnels.—The corrosion of steel rails in different localities on a railway is an interesting and important subject, bearing directly as it does on road expenses. Some particulars given in the *Engineering Record* of the wasting of steel rails in the tunnel at Land Patch, Pa., on the Baltimore and Ohio Railroad, U. S. A., which is 4,775 yards long, and which is operated with double-track traffic on a single-track line, show that the dampness and tunnel gases greatly reduce the life of the rails. Plain Bessemer rails have a life of about eighteen months, and the deterioration proceeds in the flaking of the scale from the rail until the edges of the base become quite sharp, and the rail has to be removed. At the last renewal chrome-alloy rails were substituted for Bessemer rails, and have now been in service for nearly three years. Not only have these chrome-alloy rails been found to resist corrosion much better than the Bessemer rails, but they also show fewer breakages, the number being less than one-fourth of those in the plain rails.—*Engineer.*

Cooling Mines Artificially.—In order to obviate the many economic and sanitary disadvantages connected with the increasing height of the temperature in depths below 1,000 or 1,200 meters, Messrs. Rosenbeck and Rath advocate, in a recent issue of *Gluckauf*, the installation of freezing apparatus similar to those which have been so successfully introduced, especially in tropic climes, in hospitals, slaughter-houses, theaters, market halls, etc. As specially suitable for erection underground, they recommend evaporation plants with compression pumps, the most suitable freezing agent being sulphurous acid. The plant would have to be erected in a specially constructed cooling chamber on the level it is to serve. From this chamber the cold air would be conducted to the working faces by pipes, which would, by passing through drives and crosscuts, cool the air in them as well. Although the cost of an installation sufficiently powerful to cool a mine section worked by shifts of 60 men each would amount to about $3,870, and the working costs, inclusive of interest and sinking fund, to $5,600 per annum, the authors arrive at the conclusion—which they substantiate by a series of careful calculations—that, quite apart from its sanitary advantages, the economic results achieved by such an installation in increasing the working capacity of the men, etc., would not only fully cover all expenses, but leave a profit.—*Engineering and Mining Journal.*

Trade Notes and Formulæ

Cement for Ivory.—Dissolve alum in hot water until a thick fluid mass is obtained; of this a coating is applied to each end of the broken ivory, the parts pressed together and kept in this position until the mass is dry. The cement holds very well.—*Drog. Rundschau.*

The Production of Elastic Sealing Wax—To produce seals that will neither break nor crack off, a sealing wax is to be made according to the following process: Gutta percha or caoutchouc is mixed with shellac in such proportions, that we have to 100 parts of gutta percha, 10 to 25 parts of shellac. Experiments have demonstrated that 12.5 parts of shellac imparts the best consistency to the mass. The adhesive property of the sealing wax is increased by the addition of 25 part of the commercial solution of caoutchouc in benzine. The mixture is kneaded thoroughly in a water bath, at a temperature of about 212 deg. F., coloring substance is added and the wax is shaped and finished.—*Farben-Zeitung.*

Hardening Mixture for Mill Picks.—Melt 1,000 parts of tallow, 250 parts of beeswax, 250 parts of pine rosin, and add to the melted mass 150 parts of yellow prussiate of potash. The picks, heated to redness are thrust into the cooled mass and removed when the metal can be grasped in the hand. The picks are then again heated to redness and plunged into clean, soft water, of a temperature of about 60 deg. F. for hardening. The addition of saltpeter, alkalies, salts and acids to the water, materially increases the hardness; addition of soda, fat, oil and petroleum reduces the hardness.—*Tech. Rundschau.*

Cleaning Paste for Removing Rust.—To remove rust from stove-plates, etc., we either make use of rust dissolving media, which, as they are mostly acids, are not well suited for household use, or we remove the rust by mechanical means, such as pumice stone and emery. These two substances, in combination with a fat, which will lighten the mechanical labor, furnish an excellent rust removing medium. The following is a recipe for a preparation of this character: Ground pumice stone, 40 parts; fine emery, 20 parts; petroleum, 5 parts; oleine, 35 parts; ceresine, 6 to 8 parts, by weight. Melt the ceresine, together with the oleine and after removal from the fire, stir in the petroleum, the pumice stone and emery. Continue stirring until a thick fluid consistency is attained, then pour out into cans to disguise the petroleum odor, we can perfume with a little oil of mirbane or better, with amyl acetate.—*Der Chemisch-Technische Fabrikant.*

Marble or Rubber from Ashes.—The utilization of the treasures locked up in coal has thus far usually stopped at the ashes. All the other products, such as gas, coke, tar, sulphate of ammonia, benzol, etc., have for a long time formed most important materials in our industries. In view of the enormous quantities of coal consumed annually a recently announced discovery, according to which there can be produced from ashes at will, substances resembling marble or rubber, claims lively interest. From ashes, the type of the dead, the passed away, new life is to be created. The highly excellent substance obtained, as stated, possesses at once the properties of marble and rubber. Neither moisture, heat or acids can attack it, at the same time it is non-conducting, so that its use for electric conduits also comes under consideration. The cost of producing the new substance, which is also adapted for wall and floor coverings, for table-slabs, etc., amounts to about 2 to 3 marks (45.6 to 71.4 cents) per square meter. The process of manufacture consists in that the ashes, preferably briquet ashes or dust ashes, are first sifted, then treated with cold soda water and copal varnish and finally subjected to a kneading and drying process. According to whether an imitation of marble or rubber is desired, the proper coloring substance is added. The material will be marketed under the name of "Cinerite."—*Schatze der Kohle und ihre Verwertung.*

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